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TOXICITY EVALUATION OF CONTAMINATED GROUNDWATER AT ABERDEEN PROVING GROUND-EDGEWOOD AREA WEST BRANCH OF CANAL CREEK PHASE 1: GROUNDWATER EVALUATION

INTERIM PROJECT REPORT

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Randall S. Herriott, B.S.
and
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University of Maryland at College Park
Agricultural Experiment Station
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Contracting Officers Representative: Tommy R. Shedd, M.A.
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13. ABSTRACT (Maximum 200 words) Contaminated groundwater, which contained multiple heavy metals and chlorinated aliphatic hydrocarbons, from the Canal Creek aquifer (well CC-27B) of the U.S. Army Aberdeen Proving Ground-Edgewood Area, Aberdeen, Maryland, was evaluated for toxicity to aquatic organisms. Toxicity was detected at various groundwater concentrations by 6 of 8 biomonitoring systems. The lowest concentration of groundwater that caused no observable adverse effect (NOEC) at pH 4 was 10% groundwater by volume in the following assays: 4-d green alga (Selenastrum capricornutum) growth test; 7-d cladoceran (Ceriodaphnia dubia) survival and reproduction test; and 96-h frog (Xenopus laevis) embryo teratogenesis assay - Xenopus (FETAX). A NOEC of 18% groundwater volume occurred in 7-d fathead minnow (Pimephales promelas) survival and growth tests. Buffered groundwater (pH 7) was less toxic and/or not toxic in 7-d fathead minnow tests and in FETAX assays. The 10% groundwater by volume NOECs for the green alga and cladoceran at pH 4 did not change when the organisms were exposed to buffered groundwater at pH 7. The Ames assay for mutagenicity was negative in all cases. Sporadic incidences of lesions were found in Japanese medaka (Oryzias latipes) at concentrations up to 25% groundwater by volume after 9 months of exposure. Fish growth was affected by 9 months of exposure; fish were smaller when grown in groundwater diluted with West Branch of Canal Creek water.

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P. T. Burton
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Certification of Technical Data Conformity (May 1987)

The contractor, The University of Maryland System, hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. DAMD17-92-C-2066 is complete, accurate, and complies with all requirements of the contractor.

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Senior Research Scientist

EXECUTIVE SUMMARY

The toxicological evaluation of groundwater contamination at the U.S. Army Aberdeen Proving Ground-Edgewood Area (APG-EA), West Branch of Canal Creek Area, Aberdeen, MD, was designed to be conducted in two sequential phases. Phase 1 was a determination of the potential toxicity of the groundwater in situ. If the Phase 1 evaluation showed that the groundwater was not toxic, further hazard assessment studies of the West Branch of Canal Creek ecosystem would not be necessary. Phase 2, an evaluation of the potential toxicity of the groundwater as it moves through the marsh and bottom sediments into West Branch of Canal Creek, was to be implemented if the groundwater proved to be toxic. As discussed in this report, the groundwater was found to be toxic in Phase 1. The data in Phase 1 will be integrated with the Phase 2 data to make a preliminary hazard assessment of the groundwater discharge in West Branch of Canal Creek. The Phase 2 studies and analyses will be given in a separate report.

The primary objective of Phase 1 was to evaluate the potential toxicity of the groundwater in situ to aquatic organisms because it was known that the groundwater entered the West Branch of Canal Creek ecosystem. Although microorganisms are the primary organisms present in most subsurface environments, an array of surrogate biomonitoring systems integrated into a tiered hazard framework was used in the evaluation. An array of biomonitoring assays covering several levels of biological complexity was used to maximize predictability of potential adverse pollutant effects to aquatic organisms during a 9-month evaluation. A secondary objective of Phase 1 was to evaluate, where test systems were appropriate for use in low salinity waters, the potential toxicity of West Branch of Canal Creek water. The West Branch of Canal Creek studies were conducted concurrently with the groundwater studies to obtain background data on the potential toxicity of the creek water. Only aqueous phase assays were used in the water column studies of West Branch of Canal Creek water; no sediment systems were studied.

The contaminated groundwater in the West Branch of Canal Creek study area contains multiple heavy metals and chlorinated aliphatic hydrocarbons. Groundwater was withdrawn from well CC-27B, which is one of the two most highly contaminated wells located in the Canal Creek aquifer at the West Branch of Canal Creek site.

Several U.S Environmental Protection Agency (EPA) priority pollutant heavy metals were found in the groundwater. Copper, mercury, and silver concentrations in the groundwater exceeded, in one or more tests, EPA's numerical water quality criteria for the specific metal. Aluminum was also present at high

concentrations in the groundwater; however, EPA has not finalized their draft numerical water quality criteria for the metal. Thus, it is not clear whether or not the concentrations in the groundwater may exceed EPA's numerical water quality criteria for aluminum.

Thirteen chlorinated aliphatic compounds were found in the groundwater, several of which are EPA priority pollutants. None of the priority pollutant organics found in the groundwater currently have numerical water quality criteria values; however, lowest observed effect levels (LOEL) for several of the compounds are available. All of the LOELs are one or more orders of magnitude higher than the concentrations found in the groundwater.

Eleven of the 13 volatile organics found in the groundwater had octanol water partition coefficients (log k_{ow} or log P) less than 3. Thus, bioaccumulation was not considered to be a potential toxicological problem for most of the volatile organics present in the groundwater. 1,2-Dichlorobenzene and 1,2,4-trichlorobenzene, which have K_{ows} of 3.4 and 4.2, respectively, were found in only one groundwater sample at the beginning of the study. Thus, it is difficult to determine how important bioaccumulation may be for the two compounds.

An array of eight biomonitoring systems integrated into a tiered hazard framework was used in the 9-month study. The biomonitoring systems included a number of endpoints. The pH of the groundwater from well CC-27B was ≈4; thus, many of the assays were conducted at both pH 4 and pH 7. The toxicity at pH 7 was studied so that the data could be used, if necessary, in the Phase 2 hazard assessment of the groundwater as it enters the West Branch of Canal Creek which a pH value close to the neutral range.

Toxicity was detected at various groundwater concentrations by 6 of the 8 biomonitoring systems. The Ames assay for mutagenicity was negative in all cases for groundwater, West Branch of Canal Creek water, and filtered APG-EA tap water. Differences in Japanese medaka (Oryzias latipes) growth were found in a chronic 9-month histopathology assay when the fish were exposed to 1, 5 and 25% groundwater by volume diluted with either APG-EA dechlorinated tap water or West Branch of Canal Creek surface water. In general, the fish were smaller when grown in groundwater diluted with West Branch of Canal Creek water compared to those reared in groundwater diluted with APG-EA dechlorinated tap water. Most females were larger than males when reared in groundwater diluted with either West Branch of Canal Creek water or APG-EA dechlorinated tap water.

Experimental Pathology Laboratories, Inc. (EPL), Herndon, VA, analyzed the Japanese medaka in a chronic nine-month sdudy

for incidences of hepatocellular neoplasia, neoplasms other than hepatocellular neoplasms, and non-neoplastic lesions and concluded the following. "...at nine months among male and female medaka there was no effect of groundwater on the incidence of hepatocellular neoplasia [at concentrations up to 25% groundwater by volume (highest concentrations studied) when APG-EA dechlorinated tap water was used as diluent water]." "At nine months among the males there was a slight effect of 25% groundwater concentration on the incidence of hepatocellular neoplasia...[and]...among the females there was no effect of groundwater exposure on hepatocellular neoplasia [when West Branch of Canal Creek water was used as diluent water for six months and dechlorinated tap water for three additional months]."

EPL found the following at the end of the nine-month study when Japanese medaka were initiated for 48 h at 13 days of age with 10 mg/L diethylnitrosamine (DEN). "At nine months there appeared to be a promotional effect of the groundwater at 25% concentration on hepatocellular neoplasia in male medaka (12 of 29 fish affected), although eight of 40 control medaka also had hepatocellular neoplasia at nine months [in fish exposed to 25% groundwater by volume diluted with APG-EA dechlorinated tap water]." "At nine months there appeared to be a trend of increasing percentage of hepatocellular neoplasms from controls in 25% groundwater, but the differences between groups in number of neoplasms was not great."

In DEN-initiated fish exposed to West Branch of Canal Creek water for six months followed by three months of exposure to groundwater in APG-EA dechlorinated tap water, EPL concluded "At nine months among male medaka there appeared to be a promotional effect of the groundwater on hepatocellular neoplasia based on the apparently low incidence of hepatocellular neoplasms in controls...This low incidence may be spurious..." "At six months among female medaka there appeared to be a promotional effect of the Canal Creek water on hepatocellular neoplasia. At six and nine months among female medaka there was no effect of the groundwater on hepatocellular neoplasia. The number of medaka with hepatocellular neoplasia increased at nine months over six months in all groups and at nine months the incidence was greatest among control Groups..."

The groundwater was acutely toxic at pH 4 to a green alga (Selenastrum capricornutum), cladoceran (Ceriodaphnia dubia), fathead minnow (Pimephales promelas), and Japanese medaka. From an acute toxicity standpoint, the groundwater appeared to be less toxic to the green alga at pH 7. The groundwater was not acutely toxic at pH 7 to the cladoceran, fathead minnow, or Japanese medaka.

The lowest concentration of groundwater that caused no observable adverse effect (NOEC; no-observed-effect

concentration) at pH 4, in the test systems in which the NOEC value could be determined, was 10% groundwater by volume. A NOEC of 10% groundwater by volume occurred in 3 out of 5 tests for the green alga (S. capricornutum); 4 out of 5 tests in both a 7-d cladoceran (C. dubia) and a 96-h frog (Xenopus laevis) embryo teratogenesis assay - Xenopus (FETAX). A NOEC of 18% groundwater by volume occurred in 2 of 5 tests in a 7-d fathead minnow (P. promelas) test. The groundwater was not toxic at pH 7 in the 7-d fathead minnow test and in 2 of 5 FETAX assays. The NOEC (18% groundwater by volume) was higher at pH 7 in 3 of the 5 FETAX assays. The 10% groundwater by volume NOEC for the green alga and cladoceran at pH 4, however, was essentially the same when the organisms were exposed to buffered groundwater at pH 7.

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SECTION 1

INTRODUCTION

The prediction of potential adverse toxicological effects of contaminated groundwater to aquatic ecosystems is difficult because subsurface contamination is a highly complex environmental problem. The problem is compounded when multiple contaminants of different toxicological classes are present. To assess ecological hazards of contaminated groundwater, it is necessary to understand the fate, transport, and persistence of the contaminants present in the subsurface. A number of processes, such as hydrodynamic solute transport, abiotic, biotic, and multiphase flow, can affect the fate and mobility of contaminants in groundwater (Barbee, 1994; Knox et al., 1993).

The current study is an evaluation of the toxicity of contaminated groundwater at the West Branch of Canal Creek site located in the Canal Creek area of the U.S. Army Aberdeen Proving Ground-Edgewood Area (APG-EA), Aberdeen, MD. The groundwater in the West Branch of Canal Creek site is contaminated with multiple heavy metals and chlorinated aliphatic hydrocarbons (Lorah and Clark, 1992). In 1990, the Canal Creek area was placed on the National Priorities List established under the Federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA/Superfund). The U.S. Army and the U.S. Environmental Protection Agency Region III signed an Interagency Agreement in 1990 for remedial investigation/feasibility study (RI/RF) of the area in accordance with CERCLA and applicable state law. The West Branch of Canal Creek and its surrounding marshes are the major locations in the Canal Creek area at which contaminated groundwater is currently discharging to the aquatic environment (Oliveros and Vroblesky, 1989).

The toxicological evaluation of the West Branch of Canal Creek site groundwater contamination was designed to be conducted in two sequential phases. The primary objective of Phase 1 was a determination of the potential toxicity of the groundwater in situ. The Phase 1 study was conducted in situ for two reasons. First, if the evaluation showed that the groundwater was not toxic, further hazard assessment studies of the groundwater discharge into the West Branch of Canal Creek ecosystem may not have been necessary. Secondly, if the evaluation showed that the groundwater was not toxic, treatment of the groundwater may not be necessary as a remedial action alternative to comply with CERCLA. If the in situ study had not been conducted and the Phase 2 studies (briefly discussed below) showed that the West Branch of Canal Creek sediments were toxic, it would have been difficult to differentiate between toxicity derived from 1) groundwater only, 2) toxicity from other sources, such as, former APG-EA discharges, land runoff, air deposition, etc. (Lorah and

Clark, 1992) and 3) possible toxicity interactions of contaminants from the groundwater and other sources.

A secondary objective of Phase 1 was to evaluate, where test systems were appropriate for use in low salinity waters, the potential toxicity of West Branch of Canal Creek water. The West Branch of Canal Creek studies were conducted concurrently with the in situ studies to obtain background data on the potential toxicity of the creek water. Only aqueous phase assays were used in the water column studies of West Branch of Canal Creek water; no sediment systems were studied.

Phase 2, an evaluation of the potential toxicity of the sediments impacted by the contaminated groundwater "plume" as it moves through the marsh and bottom sediments into West Branch of Canal Creek, was to be implemented if the groundwater proved to be toxic. As discussed in this report, several Phase 1 biomonitoring systems detected toxicity in the groundwater; thus, preliminary sediment studies for Phase 2 have been initiated. The results of the Phase 1 study will be integrated with the Phase 2 results and other pertinent data to derive a preliminary hazard assessment of the groundwater discharge into West Branch of Canal Creek. The Phase 2 studies and analyses will be given in a separate report.

As stated above, the objective of Phase 1 was to evaluate the potential toxicity of the groundwater in situ to aquatic organisms because it was known that the groundwater enters the West Branch of Canal Creek ecosystem. Although microorganisms are the primary organisms present in most subsurface environments, an array of surrogate biomonitoring systems integrated into a tiered hazard framework was used in the evaluation. The tiered hazard assessment approach was similar to that used in a hazard assessment evaluation of the contaminated surficial aquifer at APG-EA's Beach Point Peninsula (Burton et al., 1994). The array of biomonitoring assays, which covered several levels of biological complexity, was selected to maximize the predictability of potential adverse pollutant effects to aquatic organisms (Dutka and Kwan, 1988; National Research Council, 1981; Schaeffer and Janardam, 1987).

SECTION 2

OBJECTIVES OF STUDY

The primary objectives of the study were to:

1) Evaluate the acute toxicity of the groundwater using the 96-h EC50 algal (Selenastrum capricornutum) growth test, 48-h LC50 cladoceran (Ceriodaphnia dubia) assay, 96-h LC50 fathead minnow (Pimephales promelas) assay, and 96-h LC50 Japanese medaka (Oryzias latipes) assay. In addition, possible temporal changes in the acute toxicity of the groundwater were quantified using the 5- and 15-min Microtox® procedure (Photobacterium phosphoreum bioluminescent activity).

2) Evaluate the chronic toxicity of the groundwater using the 96-h EC50 algal (S. capricornutum) growth test, 7-d cladoceran (C. dubia) survival and reproduction test, and 7-d fathead minnow (P. promelas) survival and growth test.

3) Determine the genotoxicity potential of unconcentrated and concentrated samples of the groundwater using the Ames assay.

4) Determine the developmental toxicity potential of the groundwater using the frog (Xenopus laevis) embryo teratogenesis assay - Xenopus (FETAX).

5) Determine the chronic histopathological potential of the groundwater using a 9-month Japanese medaka (O. latipes) growth and chronic histopathology test.

6) Quantify the major chemicals present in the groundwater and monitor the general water quality of the groundwater.

7) Determine toxicity at pH 7, where appropriate, so that the data could be used, if necessary, in the Phase 2 hazard assessment of the groundwater as it enters the West Branch of Canal Creek.

The secondary objectives of the study were to evaluate the potential toxicity of West Branch of Canal Creek water using the above biomonitoring systems which were appropriate for use in low salinity water. The following evaluations were conducted:

1) Evaluate the acute toxicity of West Branch of Canal Creek water using the 96-h LC50 Japanese medaka assay. Evaluate the possible acute toxicity and temporal changes in the acute toxicity of West Branch of Canal Creek water using the 5- and 15-min Microtox® procedure.

2) Determine the genotoxicity potential of unconcentrated and concentrated samples of West Branch of Canal Creek water using the Ames assay.

3) Determine the chronic histopathological potential of the West Branch of Canal Creek water using the 9-month Japanese medaka growth and chronic histopathology test.

4) Quantify the major chemicals present in the West Branch of Canal Creek water and monitor the general water quality of the West Branch of Canal Creek water.

SECTION 3

WEST BRANCH OF CANAL CREEK SITE DESCRIPTION

The West Branch of Canal Creek is located in the Canal Creek area of the U.S. Army Aberdeen Proving Ground-Edgewood Area (APG-EA), Aberdeen, MD. As discussed in Section 3.3, West Branch of Canal Creek and its surrounding marshes are the major locations in the Canal Creek area at which contaminated groundwater is currently discharging. The studies described in Phase 1 of this report were conducted with contaminated groundwater obtained from the U.S. Geological Survey's (USGS) contaminant fate and mobility study site located in the West Branch of Canal Creek study area. Preliminary Phase 2 sediment studies (results to be given in a separate report) are being conducted with contaminated sediment also obtained from the USGS's contaminant fate and mobility study site. The USGS's West Branch of Canal Creek contaminant fate and mobility study site is bounded approximately on the northeast by Hanlon Street, southwest by West Branch of Canal Creek marshes, southeast by 35th Street, to approximately 200 m southwest of Hanlon Street. Site description data for the Canal Creek area will be discussed where appropriate for the West Branch of Canal Creek study site.

3.1 Geographic Setting and Land Use

The Canal Creek area is bordered by the Bush River and Gunpowder River which both drain to the Chesapeake Bay. Lauderick Creek and Kings Creek discharge to the Bush River on the eastern boundary of the area. The East and West Branches of Canal Creek, which provide surface drainage for a major part of the Canal Creek area, flow into the Gunpowder River on the western boundary (Lorah and Vroblesky, 1989).

Canal Creek, which provides surface drainage for a major part of the Canal Creek area, drains a land surface of more than 1,215 ha (~3,000 acres) (Lorah and Clark, 1992). The creek is tidally influenced; tidal ranges vary from about 0.15 to 0.46 m (≈0.5 to 1.5 ft) depending on the location. Wading birds, ducks, shorebirds, frogs, and muskrat can be seen in the wetland areas of Canal Creek. The creek supports a variety of freshwater and estuarine aquatic life. Marshes, which are classified as estuarine, emergent, irregularly flooded wetlands, surround West Branch of Canal Creek. The land immediately surrounding the West Branch consists of tall marsh vegetation, including grasses, sedges, cattails, Phragmites, arrowhead, and pickerelweed (Lorah and Clark, 1992). A detailed description of the plant communities associated with West Branch of Canal Creek is given in ICF Kaiser (1995).

3.2 Hydrogeology

The geology of the Canal Creek area has been described by USGS (Oliveros and Vroblesky, 1989). Briefly, the Aberdeen Proving Ground-Edgewood Area is underlain by Coastal Plain sediments consisting of unconsolidated clay, silt, and sand layers with occasional gravel lenses. The Coastal Plain sediments dip southeastward, increasing to a thickness of ≈400 ft in the eastern part of the Canal Creek area. Three aquifers and two confining units are present in most of the Canal Creek area as follows: 1) the surficial aquifer; 2) the upper confining unit; 3) the Canal Creek aquifer; 4) the lower confining unit; and 5) the lower confined aquifer.

The Canal Creek aquifer is the major aquifer underlying most of the Canal Creek area with a thickness ranging from 9.1 to 21.3 m (30 to 70 ft). As discussed by Lorah and Clark (1992), the aquifer is unprotected by a surficial clay layer where the upper confining unit is absent. The upper confining unit is absent in two areas that extend approximately parallel to the present courses of the East and West Branches of Canal Creek (Lorah and Clark, 1992). Near the West Branch of Canal Creek, the upper confining unit and Canal Creek aquifer begin to outcrop, leaving the Canal Creek aquifer exposed to the surface. That is, a direct hydraulic connection exists between the surficial aquifer and the Canal Creek aquifer near the West Branch of Canal Creek because of the absence of the upper confining unit. This part of the Canal Creek aquifer has been designated "unconfined" by Oliveros and Vroblesky (1989).

A Pleistocene paleochannel eroded the sediments of the upper confining unit near the East Branch of Canal Creek. As a result, the sediments of the Canal Creek and surficial aquifers are directly connected. The Canal Creek aquifer becomes truly confined east and south of the paleochannel where the aquifer dips approximately 15.2 m per 1,609 m (50 ft/mile) under the thickening upper confining unit. The upper confining unit is over 100 ft thick in the extreme southeastern part of the Canal Creek area.

The surficial aquifer (0 to 9.1 m; 0 to 30 ft), which overlies the Canal Creek aquifer, becomes discontinuous and pinches out east and northeast of the paleochannel (Lorah and Clark, 1992). Isolated portions of the surficial aquifer are present south of Kings Creek and at Beach Point. The lithology of the surficial aquifer is highly variable. The lower confining unit and lower confined aquifer underlie the Canal Creek aquifer. The lower confining unit has a thickness of 10.7 to 19.8 m (35 to 65 ft). The lower confined aquifer appears to be continuous over the entire Canal Creek area.

3.3 Groundwater Flow

The Canal Creek aquifer contains two separate flow systems: one unconfined and part of the local flow system, and one confined and part of the regional flow system (Oliveros and Vroblesky, 1989). The local flow system occurs where the upper confining unit is absent near the West Branch of Canal Creek and the paleochannel near the East Branch of Canal Creek. Groundwater in the local flow system of the Canal Creek aquifer discharges vertically upward to the surficial aquifer or directly to the surface-water bodies, whereas groundwater in the regional flow system moves southeast and dips down into the deeper confined flow system (Loran and Clark, 1992). Equipotential mapping of the Canal Creek aquifer shows that the groundwater divide between the eastward and westward flowing portions of the Canal Creek aquifer runs ≈ 1,400 m (4,700 ft) in a north south direction from the Route 24 entrance of the Edgewood Arsenal (approximately parallel to Hoadley Road) to approximately the same latitude as the confluence of the East and West Branches of Canal Creek (JEG, 1995).

Although the hydraulic heads in the Canal Creek aquifer show characteristics of local flow conditions near both branches of Canal Creek, the aquifer is most strongly influenced by the presence of the West Branch of Canal Creek because the aquifer is largely unconfined near this creek branch (Lorah and Clark, 1992). As discussed by Lorah and Clark (1992), the upper part of the Canal Creek aquifer at sites located near the West Branch of Canal Creek has been hydrologically defined as the "surficial aquifer" because it behaves as a water table aquifer. Near the West Branch of Canal Creek, hydraulic head distributions in this water table aquifer are very similar to the heads measured in wells screened in the lower part of the Canal Creek aquifer. Large bends in the hydraulic head contours around the West Branch of Canal Creek indicate that groundwater in both the lower and upper parts of the Canal Creek aquifer flows toward and discharges to the West Branch of Canal Creek. Some groundwater flow also occurs toward the East Branch of Canal Creek near the junction of both branches of Canal Creek. Groundwater flow in the Canal Creek aquifer near the West Branch of Canal Creek is also affected by drainage into a network of leaky sewers and storm drains (Oliveros and Vroblesky, 1989).

The Canal Creek aquifer receives recharge from three sources: 1) downward flow from the surficial aquifer; 2) upward recharge from the lower confined aquifer; and 3) precipitation infiltrating to the aquifer from updip, west and north of the Canal Creek area (Oliveros and Vroblesky, 1989). Recharge from the surficial aquifer occurs in several areas that contain a number of former activities which may have contributed to contamination; thus, the Canal Creek aquifer is more susceptible to contamination in these recharge areas (Lorah and Clark, 1992).

The surficial aquifer receives recharge from direct infiltration of precipitation or surface water and from upward leakage from the Canal Creek aquifer (Lorah and Clark, 1992). Direct infiltration can occur over most of the aquifer surface. As discussed by Lorah and Clark (1992), the surficial aquifer discharges to surface water, to leaky sewers and storm drains, and to the Canal Creek aquifer. Much of the downward discharge from the surficial aquifer to the Canal Creek aquifer probably returns as recharge to the surficial aquifer at topographic lows; however, some may enter the regional flow system of the Canal Creek aquifer and move to the southeast to discharge off-site.

Present water level fluctuations in the Canal Creek area are caused by rainfall and tidal effects (Lorah and Clark, 1992). At any given site, the maximum seasonal fluctuation in water levels observed in the Canal Creek aquifer is 0.6 to 0.9 m (2 to 3 ft). Seasonal changes in hydraulic heads in the Canal Creek aquifer are most pronounced in the unconfined parts of the aquifer. Hydrograph recordings from a well screened in the unconfined Canal Creek aquifer near the West Branch of Canal Creek show a rise in water levels generally during the spring when rainfall and recharge are greatest; a decline in water levels generally occurs in the late summer to early fall when rainfall is the least.

In the surficial aquifer, seasonal differences in head are greatest in relatively shallow, hydrologically isolated parts of the aquifer located east of the East Branch of Canal Creek (Lorah and Clark, 1992). Seasonal differences in head as high as 1.7 m (5.5 ft) have been recorded in the surficial aquifer. Seasonal fluctuations in the lower confined aquifer generally are less pronounced than those in the Canal Creek aquifer or surficial aquifer. Groundwater flow directions in the three aquifers do not vary significantly over the Canal Creek area because of seasonal fluctuations. Pumping stresses do not currently affect groundwater flow within the Canal Creek area (Lorah and Clark, 1992).

3.4 Historical Use

The Canal Creek area has been used for a number of activities which may have contributed to the contamination of the soils, groundwater, and marshes of the creeks (Nemath, 1989). Nemath (1989) has discussed in detail the major activities which were known to have occurred since 1917 in the Canal Creek area. The activities included manufacturing, filling of munitions, and waste disposal. Lorah and Vroblesky (1989) summarized Nemath's report of past activities and briefly discussed those plants and activities that are believed to have had the greatest potential for environmental impact. The following is a brief summary taken primarily from Lorah and Vroblesky (1989).

Five major production-scale activities occurred at Canal Creek. They included the manufacturing of chlorine, mustard (primarily sulfur mustard), chloroacetophenone, impregnite material [N,N'-dichloro-bis-(2,4,6-trichlorophenyl)urea], and the impregnating of protective clothing. The plants were most active during World Wars I and II. Pilot, or experimental, manufacturing was performed to gather data on manufacturing processes in support of the larger production-size activities. Munitions filling operations have been conducted from 1918 to the present. Other activities that also may have affected the environment include the operation of machine and maintenance shops, motorpool garages, and the airfield.

The primary method of waste disposal from WWI until recently was by discharge to sewer systems. As discussed by Lorah and Vroblesky (1989), the sewer lines from the majority of the manufacturing and munitions filling plants discharged to the East or West Branches of Canal Creek. Exceptions include a pilot plant east of the airport, which discharged to Kings Creek, and the mobile clothing-impregnating units that operated at Beach Point, which discharged to the Bush River and Kings Creek. Solid wastes, such as, sludges and tars, were discharged through the sewers if the wastes could be thinned with water or held at elevated temperatures to keep them fluid.

Wastes generally received little or no treatment prior to discharge before and during WWII (Lorah and Vroblesky, 1989). Wastes that could not be discharged through the sewer systems were often dumped into the marshy areas along Canal Creek. A number of disposal pits, a sand pit, salvage yard, and a fire-training pit were used throughout Canal Creek for various operations. Waste treatment increased after WWII with the increased awareness of environmental concerns and regulations.

Organic solvents, such as carbon tetrachloride, 1,1,2,2-tetrachloroethane, and trichloroethylene, were some of the most common wastes produced in large quantities from the manufacturing, munitions filling, and other miscellaneous activities in the Canal Creek area (Lorah and Vroblesky, 1989). All the major manufacturing plants, except for the chlorine plants, used solvents as raw materials, decontaminating agents, and cleaning agents. A number of heavy metals were used in various processes but in much smaller quantities than the organic solvents (Nemath, 1989).

3.5 Groundwater Contamination

Few studies of groundwater contamination were conducted prior to 1985 in the Canal Creek area (Nemath, 1989, Lorah and Vroblesky, 1989). The USGS initiated a 5-year study in 1985 to determine the extent of groundwater contamination in the Canal Creek area (Lorah and Clark, 1992). The observation well network

that was established in the Canal Creek area included 87 wells installed during the first phase of the study and 65 wells installed during the second phase to further define the extent and sources of contamination. The observation wells were installed at a total of 77 sites that generally consist of clusters of two to six wells screened at different depths; only one well was placed at some sites. The sites were chosen on the basis of historical information regarding chemical manufacturing and waste disposal areas. The wells were screened in the three major aquifers with the majority of the wells screened in the Canal Creek aquifer.

A number of well sites were established near West Branch of Canal Creek (Lorah and Clark, 1992). Approximately 24 sites were established in the first-phase of drilling followed by an additional 12 sites in the second phase. A detailed description of the suspected sources near West Branch of Canal Creek and the well sites are given in Lorah and Clark (1992); thus, the information will not be repeated in this report.

Chemical monitoring (inorganic and organic constituents) by USGS confirmed that hazardous chemicals from prior activities were widespread in the surficial and Canal Creek aquifers (Lorah and Clark, 1992). No contamination was detected in the lower confined aquifer, which is protected by a clay unit that underlies the Canal Creek aquifer. Fifteen inorganic constituents were present in the surficial aquifer in concentrations that exceed current or proposed drinking water regulations established by the U.S. Environmental Protection Agency (EPA). They included dissolved solids, chloride, iron, fluoride, manganese, aluminum, antimony, arsenic, beryllium, cadmium, chromium, lead, mercury, nickel, and thallium. In addition, copper and zinc were present in groundwater in elevated concentrations compared to background concentrations in the study area (Lorah and Clark, 1992).

Chlorinated volatile organic compounds were the dominant groundwater contaminants and included 1,1,2,2-tetrachloroethane, trichlorethylene, chloroform, 1,2-trans-dichloroethylene, and carbon tetrachloride (Lorah and Clark, 1992). Additional volatile organic compounds included benzene, chlorinated benzenes, pentachloroethane, and several unknown compounds. Semi-volatile organic contaminants were not as widely distributed in the groundwater as the volatile compounds. Nitrobenzene, 1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, and two mustard degradation products (dithiane and 1,4-oxathine) were present at three or fewer sites. Other semi-volatile contaminants that were reported (tentatively identified) in some samples include hexachloroethane, 1,2-dibromoethene, tribromethane, naphthalene, various compound related to petroleum fuels, and unknown compounds (Lorah and Clark, 1992).

3.6 Sediment Contamination

The contaminants present in the sediments of Canal Creek have been investigated by ICF Kaiser (1995). A total of 14 sediment samples were taken from Canal Creek and analyzed for inorganic and organic contaminants and toxicity to an aquatic organism. Five samples were taken from West Branch of Canal Creek; five from East Branch of Canal Creek; and four below the confluence of the West and East Branches of Canal Creek. Most of EPA's priority pollutant heavy metals (selenium and thallium were not measured) were found in the sediments of all 14 stations with the exceptions of cadmium which was present at 9 of 14 stations, nickel at 11 of 14 stations, and silver at 7 of 14 stations. Cadmium, mercury, and zinc were judged by ICF Kaiser (1995) to be inorganic chemicals of potential concern which may impact benthic organisms. Cadmium was found at concentrations to be judged a chemical of concern in West Branch of Canal Creek sediment taken from the current study site.

A number of organic contaminants were also found in the sediments at one or more of the 14 stations sampled during the ICF Kaiser (1995) study. The following organic chemicals of concern were found at the highest concentrations of the 14 stations in the sediments taken from the West Branch of Canal Creek study site: pesticides/aroclors (Aroclor-1260, α-BHC, dieldrin, and endosulfan I); polycyclicaromatic hydrocarbons (phenanthrene); explosives [N,N-bis(2,4,6-trichlorophenyl)urea and nitroglycerin]; and other volatiles/semi-volatiles (1,2,4-trichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 2,4,6-trichlorophenol, 4-chloroaniline, and pentachlorophenol).

Twenty-eight day chronic toxicity tests were conducted with the amphipod, Hyalella azeteca, to determine the potential toxicity of the Canal Creek sediments to benthic organisms (ICF Kaiser, 1995). Significant mortality occurred to amphipods at two of the 14 stations in Canal Creek; significant reductions in growth occurred at a third station. Significant mortality occurred in West Branch of Canal Creek sediment taken from the current study site and at one station at the confluence of West and East Branches of Canal Creek. Growth was significantly reduced at one station in East Branch of Canal Creek. ICF Kaiser (1995) concluded that the biological effects occurred at chemical "hot spots", that is, the observed reductions in survival and growth occurred in sediments where high chemical concentrations were detected.

3.7 Surface Water Contamination

The contamination of Canal Creek surface waters was also studied during the 5-year USGS study initiated in 1985 (Lorah and Clark, 1992). Surface water samples were collected from the West and East Branches of Canal Creek, at the mouth of the Gunpowder

River, and from the area that borders Beach Point in Kings Creek and the Bush River. Most of the surface water sampling sites were located where contaminated groundwater was most likely to discharge and near past sewerline discharge points in the Canal Creek area. Sampling sites were most heavily concentrated along the West Branch of Canal Creek and around Beach Point because preliminary data indicated that many sources of shallow contaminated groundwater and wastewater existed in these areas.

Five inorganic constituents were found in surface water samples that were collected from West Branch of Canal Creek in concentrations that exceed EPA's acute or chronic aquatic life criteria for freshwater organisms. The five inorganic contaminants included cadmium, iron, lead, mercury, and zinc. According to Lorah and Clark (1992), a major source of the inorganic contaminants may be the remobilization of metals that accumulated in bottom sediments from the discharge of untreated industrial wastewaters.

The same volatile organic compounds that were the major groundwater contaminants were detected in surface water samples. The discharge of shallow contaminated groundwater is probably the major source of the surface water contaminants (Lorah and Clark, 1992). According to Lorah and Clark (1992), dissolution of dense non-aqueous phase liquids (DNAPL) that are still present in the bottom sediments may be a likely source of the volatile organic contaminants found in the surface waters. Phthalate esters, which are common laboratory contaminants, were the only organic compounds detected in the surface water samples in concentrations that exceeded either acute or chronic ambient water quality criteria for freshwater aquatic life.

SECTION 4

MATERIALS AND METHODS

4.1 General

Groundwater was withdrawn from well CC-27B (Harford County Permit No. HA-81-3062) which is one of two of the most highly contaminated wells at the West Branch of Canal Creek site (Lorah and Clark, 1992). The well is 12.2 m deep (40 feet) and has a screened interval of 10.7-12.2 m (35-40 ft). The well pump intake was located at 11.3 m (37 feet). Groundwater was pumped continuously from the well at a rate of ≈7.5 L/min (2 gal/min).

Several components of the biomonitoring study were conducted on-site (see below) in an aquatic biomonitoring trailer with bioassay capabilities similar to a CEHR trailer described by Herriott and Burton (1992). Two sources of dilution water were used in the studies. The first was APG-EA potable drinking which was charcoal filtered, aerated before use, and adjusted to ≈25 °C as described in Herriott and Burton (1992). The second source was surface water pumped from the West Branch of Canal Creek. A stainless steel pump, which was placed in a PVC pipe housing (25.4 cm O.D.; 10 inches) in the creek to protect the pump from floating debris, supplied ≈7.5 L/min (≈ 2 gal/min) to the biomonitoring trailer. The creek water was filtered at ≈80 μ before use. Groundwater, West Branch of Canal Creek water, and APG-EA tap water were supplied to the trailer via polyethylene pipe. Excess groundwater, creek water, and tap water from the trailer were collected, treated via charcoal, and discharged to the APG-EA Wastewater Treatment Plant collection system.

An array of 8 biomonitoring systems were evaluated during the 9-month study which ran from August 15, 1994 to May 10, 1995. The biomonitoring systems included a number of endpoints. A brief summary of the biomonitoring tests conducted and the dates of the studies is given in Table 1. The pH of the groundwater from well CC-27B was ≈4; thus, many of the assays were conducted at both pH 4 and pH 7. The toxicity at pH 7 was studied so that the data could ultimately be used in a hazard assessment of the groundwater as it enters the West Branch of Canal Creek which generally has a pH in the low neutral range.

Although microorganisms are the primary organisms present in most subsurface environments, an array of surrogate biomonitoring systems integrated into a tiered hazard framework was used in the groundwater evaluation. The array of biomonitoring assays covered several levels of biological complexity to maximize the predictability of potential adverse pollutant effects to aquatic organisms. Although the groundwater ultimately discharges into the West Branch of Canal Creek, freshwater surrogate

TABLE 1. SUMMARY OF THE BIOMONITORING TESTS CONDUCTED[a]

Test and/or Species	Type of Test	Test No.	Test Periods
Microtox® (bacterium)	5- and 15-min EC50	N/A	08/15/94 - 05/10/95
Green alga	96-h EC50; 96-h Growth	1	09/13/94 - 09/17/94
		2	11/11/94 - 11/15/94
		3	01/24/95 - 01/28/95
		4	03/24/95 - 03/28/95
		5	05/03/95 - 05/07/95
Cladoceran	48-h LC50; 7-d Survival and reproduction	1	09/13/94 - 09/20/94
		2	11/08/94 - 11/15/94
		3	01/24/95 - 01/31/95
		4	03/24/95 - 03/31/95
		5	05/03/95 - 05/10/95
Fathead minnow	96-h LC50; 7-d Survival and growth	1	09/13/94 - 09/20/94
		2	11/08/94 - 11/15/94
		3	01/24/95 - 01/31/95
		4	03/24/95 - 03/31/95
		5	05/03/95 - 05/10/95
Japanese medaka	96-h LC50	1	10/11/94 - 10/15/94
		2	12/12/94 - 12/16/94
		3	02/06/95 - 01/10/95
		4	04/07/95 - 04/11/95
		5	05/08/95 - 05/12/95
Genotoxicity (bacterium)	Ames assay	1	09/12/94
		2	11/07/94
		3	01/23/95
		4	03/23/95
		5	06/07/95
Developmental toxicity (African clawed frog)	4-d FETAX	1	09/16/94 - 09/20/94
		2	11/11/94 - 11/15/94
		3	01/25/95 - 01/29/95
		4	03/24/95 - 03/28/95
		5	05/03/95 - 05/07/95
Chronic histopathology and growth (Japanese medaka)	6-m exposure	N/A	08/12/94 - 02/08/95
	9-m exposure	N/A	08/12/95 - 05/10/95

TABLE 1. (CONTINUED)

Test and/or Species	Type of Test	Test No.	Test Periods
Comprehensive chemical analyses	N/A	1	09/12/94
		2	11/07/94
		3	01/23/95
		4	03/23/95
		5	05/02/95
Munitions analyses	N/A	1	09/16/94
		2	11/09/94
		3	01/23/95
		4	04/21/95
		5	04/28/95
Routine water quality analyses	N/A	N/A	Daily/weekly

[a] See Section 4 for a description of the test method, various media sampled, types of samples taken, etc., for each test system.

biomonitoring systems were used in the evaluation because the groundwater was freshwater. An argument can be made that low saline organisms should also have been included because the West Branch of Canal Creek is a freshwater/low salinity system influenced primarily by tidal flux and rainfall. However, as stated in the Introduction, the primary goal of the groundwater study was to evaluate the toxicity of the groundwater in situ. Thus, low salinity organisms were not included in the biomonitoring array.

In addition to the groundwater studies, several studies were conducted to determine the potential toxicity of West Branch of Canal Creek water. Only those test systems that were appropriate for use in low salinity waters were used in the evaluation. Aqueous phase assays were used in the water column studies of West Branch of Canal Creek water; no sediment systems were studied.

The experimental procedures and frequency of each assay are described in detail below. The following is a brief description of the tier of biomonitoring systems employed in the evaluation. Acute toxicity of the groundwater was evaluated three times each week using the 5- and 15-min Microtox® assay which uses microbial (Photobacterium phosphoreum) bioluminescent activity. In

addition to providing rapid toxicity data, the test was also conducted to monitor the toxicity of the groundwater over time. Acute toxicity data were also obtained for the Japanese medaka (Oryzias latipes) and the algal, invertebrate, and fish used in the short-term toxicity tests described in Section 4.2 below. The algal, invertebrate, and fish assays were conducted five times on a bimonthly basis during the course of the study at a pH of 4 and 7.

The following 4- to 7-d short-term toxicity tests, which were used to estimate chronic toxicity, were performed on a bimonthly basis: 96-h algal (Selenastrum capricornutum) growth test; 7-d cladoceran (Ceriodaphnia dubia) survival and reproduction test; and 7-d fathead minnow (Pimephales promelas) survival and growth test. Five bimonthly tests were conducted with each species at pH 4 and pH 7. In addition to the short-term methods used to estimate chronic toxicity, growth data at 6 and 9 months from the chronic Japanese medaka histopathology test described below were also used as chronic toxicity endpoints.

Gene mutation potential was determined using the Ames Salmonella/mammalian-microsome reverse assay. Developmental toxicity was determined by the 96-h frog embryo teratogenesis assay-Xenopus (FETAX) using the African clawed frog, Xenopus laevis. Genotoxicity and developmental toxicity assays were conducted at bimonthly intervals during the same periods as the above acute and short-term chronic tests were conducted. Chronic histopathological changes were evaluated using the Japanese medaka as the experimental model. Both unexposed and fry exposed to diethylnitrosamine (DEN) were exposed continuously under flow-through test conditions for 6- and 9-month exposure periods. Identical exposures were performed using both APG-EA tap water and West Branch of Canal Creek water as diluent water sources.

Comprehensive chemical analyses of the raw groundwater, filtered APG-EA tap water, West Branch of Canal Creek water, and test dilutions in the chronic histopathology assay were performed five times at bimonthly intervals. The chemical analyses were conducted during the same periods that the above bimonthly assays were conducted. Routine water quality analyses were also conducted at various frequencies on a weekly basis.

4.2 Acute Toxicity Tests

4.2.1 Microtox®

The Microtox® test (Microbics Corp., Carlsbad, CA) is a rapid acute toxicity test that may be completed in less than one hour. The test is based on the reduction in bioluminescence of the marine bacterium P. phosphoreum when exposed to a sample of unknown toxicity. The degree of light reduction, an indication of metabolic inhibition in the test preparation, indicates the

degree of toxicity of the sample. The Microtox® test procedures followed were those outlined in Herriott and Burton (1992) which were derived from Microtox®'s operating manual (Microtox®, 1988). A Microtox® Model 500 Analyzer with PC version 6.3 software was used for both a 5-min and 15-min test on all samples.

Several sources of water were assayed on-site over the 9-month test period. With the exception of two samples, all samples were composite grab samples taken from the 9-month histopathology exposure tanks as described in Section 4.6. Grab samples were taken directly from the groundwater supply line and the West Branch of Canal Creek (special 2-month volatile organics study described below) water supply line as they entered the biomonitoring facility. The West Branch of Canal Creek samples taken from the 9-month histopathological exposure aquaria were composite grab samples (see below). All assays were conducted three times per week with the exception of the APG-EA tap water and West Branch of Canal Creek supply water volatile organics study which were assayed weekly as described below.

The following Microtox® assays were conducted three times a week from August 15, 1994 until the biomonitoring study was completed on May 10, 1995. Both 5- and 15-min assays were conducted on 100% groundwater, 25% groundwater by volume diluted with APG-EA tap water, and 100% West Branch of Canal Creek water. The 25% groundwater by volume samples were composite grab samples taken from the chronic histopathology study tanks as described below in Section 4.6. A 25% groundwater by volume composite grab sample taken from the chronic histopathology study tanks diluted with West Branch of Canal Creek water was scheduled to be taken throughout the 9-month exposure period. However, as explained in Section 4.6, the assays were discontinued after six months (February 5, 1995), because the diluent water was switched from West Branch of Canal Creek water to APG-EA tap water.

Five- and 15-min assays were conducted three times per week for ≈1.5 months (August 15, 1994 to October 5, 1994) on 5 and 1% groundwater by volume samples taken from the 9-month histopathology tanks diluted with both APG-EA tap water and West Branch of Canal Creek water (Section 4.6). The assays were terminated after ≈1.5 months because no toxicity was observed. Weekly assays were conducted for two months (September 2, 1995 to November 5, 1994) on grab samples of 100% West Branch of Canal Creek water taken directly from the fed line as it entered the biomonitoring trailer. These assays were conducted to determine whether or not trace volatile organics in West Branch of Canal Creek water were present at concentrations high enough to cause toxicity before possible volatilization occurred in the 100% control West Branch of Canal Creek histopathology aquaria (Section 4.6). The assays were discontinued after two months of study because no toxicity was detected in the raw West Branch of Canal Creek water.

Standard 5- and 15-min Microtox® assays were conducted once per week on grab samples of 100% APG-EA tap water during the 9-month test period. A previous study of charcoal filtered APG-EA tap water showed that no toxicity existed in the tap water (Burton et al., 1994). Thus, only weekly samples rather than three samples per week were assayed to confirm the earlier finding. Five- and 15-min assays of raw groundwater buffered with 10 N NaOH to a pH of ≈7 were run for 9-months to determine the effect of pH on the toxicity observed for raw 100% groundwater at a pH of ≈4.

4.2.2 Green Alga, Cladoceran, Fathead Minnow, and Japanese Medaka

Acute toxicity values were calculated where possible at pH 4 and 7 for the green alga, cladoceran, and fathead minnow from the data obtained during the short-term chronic tests described in Section 4.3. With regard to the green alga, EPA's Office of Research and Development considers the 96-h algal test for growth to be a short-term chronic test for determining the toxicity of effluents (Horning and Weber, 1985; Weber et al., 1989) as do other investigators for evaluating single chemicals (for ex., see Hughes et al., 1988 and Suter, 1993). EPA's Toxic Substance Control Act office considers the 96-h test to be an acute test (U.S. EPA, 1985 and 1986a). Because we used the short-term chronic method (Section 4.3.1), we analyzed the data as chronic data; however, we also analyzed and reported the results as 96-h acute data so that acute:chronic ratios could be calculated, if needed, for later use in a hazard assessment. Forty-eight-h LC50s and 96-h LC50s were determined where possible for the cladoceran and fathead minnow, respectively.

Five bimonthly 96-h static renewal acute toxicity tests were conducted on-site at 25 °C with the Japanese medaka at a pH of 4 and 7 using the procedure of Weber (1991). All dilutions were renewed daily with groundwater obtained just prior to the renewal. In addition to the 96-h LC50 bioassays using APG-EA tap water as the dilution water, 2 replicates of 10 fish/replicate were exposed to 100% West Branch of Canal Creek water (static renewal every 24 h). The West Branch of Canal Creek exposure was conducted to provide additional supporting data for the long-term exposure of Japanese medaka to West Branch of Canal Creek diluent water discussed in Section 4.6. Routine water quality was taken at the beginning and end of each 24-h renewal. The methods used for the chemical analyses are discussed in Section 4.7.2.

4.3 Short-term Chronic Toxicity Tests

The specific test methods for the short-term chronic tests are given below. Deviations from the test methods are discussed where appropriate. A geometric series of five groundwater concentrations (plus controls) was used in all tests. The

groundwater samples used in the tests were obtained daily and used within 6 h at each 24-h renewal (see below). All groundwater samples were transported in glass containers on ice and held at 4°C until used for the tests. Each groundwater sample was split into two aliquots. One aliquot was maintained at pH 4 and the second buffered to pH 7 (10 N NaOH). All five bimonthly short-term chronic bioassays were conducted at pH 4 and 7. The same pH-adjusted aliquots were also used for the FETAX assays discussed in Section 4.5. In addition to the standard bioassays with groundwater, a 100% APG-EA tap water sample was run concurrently with each short-term chronic test to provide supporting toxicological data for the APG-EA tap water used in the chronic histopathology exposures (Section 4.6). All bioassays were conducted at the University of Maryland Wye Research and Education Center (UMD/WREC) Aquatic Toxicology Laboratory.

4.3.1 Green Alga

The short-term chronic toxicity of the groundwater to the green alga (S. capricornutum) at pH 4 and 7 (10 N NaOH) was determined five times by the EPA procedures given in Weber et al. (1989). A starter culture of S. capricornutum was obtained from the culture collection at the University of North Texas, Denton, TX. Stock algal cultures were reared in 2.5 L Pyrex culture flasks containing 1 L of sterilized double strength "AAP" algal assay medium, with sufficient P added to achieve a 20:1 N:P ratio as described in Miller et al. (1978). Cultures were maintained in a constant temperature incubator under constant cool-white fluorescent lights (≈300 foot candles) at a temperature of 25 ± 0.2°C on a shaker table oscillating at 100 rpm (± 10 %). Log growth cells were used to start all tests.

Algal test solutions were prepared by dilution of the groundwater with filtered sterilized assay media. Test solutions (100 mL total volume) were dispensed into 250 mL Delong flasks and inoculated with S. capricornutum cells in log growth to achieve a density of ≈1 x 10^4 cells/mL. Triplicates were prepared for each treatment. The flasks were placed on a shaker table in an incubator set at the culturing conditions described above. Growth measurements (cell density) were made from all replicates in each treatment at 0, 24, 48, 72, and 96 h. Algal cell density was determined from a 1 mL sample with a Model ZBI Coulter Counter (Coulter Electronics, Inc., Hialeah, FL). The instrument was calibrated with each use via hemocytometer counts. Test solutions were not renewed during the 96-h studies.

4.3.2 Cladoceran

The chronic toxicity of the groundwater at pH 4 and 7 to C. dubia was determined five times by the EPA static renewal method (solutions renewed daily) given in Weber et al. (1989). The

cladoceran was cultured at 25 ± 1°C in 600 mL glass beakers filled with 400 mL of 20% Perrier:80% reverse osmosis water amended with selenium (2 µg Se/L as Na_2SeO_3) as recommended by Winner (1989). The diet consisted of a mixture of Cerophyl® (Cerophyl Laboratories, Inc., Kansas City, MO) and the green alga, S. capricornutum, added to the cladoceran culture to achieve final concentrations of 120 µg Cerophyl®/mL and 6.7×10^5 S. capricornutum cells/mL. Starter cultures of C. dubia were obtained from the Center for Lake Superior Environmental Studies, University of Wisconsin - Superior.

All neonates used in the 7-d survival and reproduction tests were produced by cladocerans in culture that had released at least three broods. The initial age of the neonates in each test was <4 h old. The tests were conducted in 50 mL glass beakers containing 30 mL of test solution. All tests were conducted in an environmental chamber at 25 ± 1°C under a 16-h light:8-h dark photoperiod (fluorescent lights; 60-85 foot candles at the surface of the culture vessels). All test organisms were fed daily as described above at each 24-h renewal. Routine water quality was taken at the beginning and end of each 24-h renewal. The methods used for the chemical analyses are discussed in Section 4.7.2.

4.3.3 Fathead Minnow

The toxicity of the groundwater at pH 4 and 7 to fathead minnows (P. promelas) was determined five times by the EPA static renewal method (solutions renewed daily) given in Weber et al. (1989). All larvae used in the 7-d survival and growth tests were <24 h old at the start of the test. The tests were conducted in 600 mL glass beakers containing 400 mL of test solution. The dilution water was a 20% Perrier:80% reverse osmosis water. All test organisms were fed brine shrimp (Artemia sp.) nauplii <24 h old daily at each 24-h renewal. All tests were conducted at 25 ± 1°C under a 16-h light:8-h dark photoperiod (fluorescent lights; 60-85 foot candles). Routine water chemistry was performed at the beginning and end of each renewal. Dry weight was determined by drying at 100°C for a minimum of 12 h.

Fathead minnow larvae were obtained from the UMD/WREC culture maintained at 25 ± 1°C in UMD/WREC non-chlorinated well water (mean dissolved oxygen = 8.2; conductivity = 161 µs/cm; alkalinity = 53 mg/L as $CaCO_3$; hardness = 52 mg/L as $CaCO_3$; pH ranged from 7.1 to 8.0). The UMD/WREC culture procedures were similar to those recommended by Peltier and Weber (1985). The UMD/WREC culture was initiated with mature fathead minnows obtained from the U.S. EPA Environmental Monitoring and Support Laboratory - Cincinnati, Ohio.

Spawning fish were cultured in fiberglass tanks (2.4 x 0.8 x 0.5 m) containing 0.2 m UMD/WREC well water held at 25 ± 1°C. The spawning adults were fed a diet of frozen brine shrimp (Artemia sp.; Argent Chem. Lab., Redmond, WA) and TetraMin® Staple Food (Ramfab Aquarium Products Co., Oak Ridge, TN) twice daily. Excess food was removed daily. Four sets of spawning fathead minnows were maintained in the culture tanks at a ratio of 1 male:4 females. Replacement spawners were rotated at approximately 3-month intervals. Fathead minnow embryos were collected on spawning substrates (10 cm I.D. x 20 cm long PVC pipe sections cut longitudinally in equal portions) and transferred to 19 L aquaria at 25 ± 1°C in UMD/WREC well water for hatching. All stages of the fish were reared under a 16-h light:8-h dark photoperiod (fluorescent lights; 60-85 foot candles).

4.4 Genotoxicity Test

The Ames assay was used to evaluate the mutagenic potential of unconcentrated and concentrated groundwater, APG-EA tap water, and West Branch of Canal Creek water. This assay system has been shown to detect a diverse group of chemical mutagens (McCann et al., 1975 and McCann and Ames, 1976). The ability to predict chemical mutagenic activity may also serve as a carcinogen prescreen test (Ames et al., 1973). The ability to induce mutation is indicative of a chemical's genotoxic potential. Salmonella typhimurium/mammalian-microsome reverse mutation assays were conducted five times on the raw groundwater, APG-EA tap water, and West Branch of Canal Creek water samples described below. The assays were conducted on both unconcentrated and concentrated (100X via extraction in methylene chloride followed by rotoevaporation) samples as described below. The Ames mutagenicity assays were conducted by Microbial Associates, Inc., Rockville, MD.

Grab samples of raw groundwater were taken directly from the fed line to the biomonitoring laboratory. The first three of five West Branch of Canal Creek samples were taken via composite grab samples from the chronic histopathology exposure tanks; samples four and five were taken directly from West Branch of Canal Creek (Section 4.5). Grab samples of APG-EA tap water were taken via composite grab samples from the chronic histopathology exposure tanks. One liter samples of each material were siphoned into glass containers with no head space, packed in ice, and transported in insulated containers to Microbial Associates, Inc.

The following five sample sets were analyzed at approximately bimonthly intervals over the 9-month study. Both unconcentrated and concentrated (100X) analyses were conducted on groundwater, APG-EA tap water, and West Branch of Canal Creek water during the first sample period. During the second, third, and fourth sample periods, both unconcentrated and concentrated

analyses were conducted on groundwater and West Branch of Canal Creek water; APG-EA tap water was not analyzed. Concentrated samples only of groundwater, APG-EA tap water, and West Branch of Canal Creek water were analyzed during the fifth sample period.

The unconcentrated and concentrated (100X) samples were analyzed by Microbial Associates, Inc. Protocol No. SPGT501005 (Microbiological Associates, Inc., 1994). Briefly, the mutagenicity assays evaluated the groundwater, APG-EA tap water and West Branch of Canal Creek samples for their ability to induce reverse mutations at the histidine locus in the genome of specific S. typhimurium tester strains both in the presence and absence of an exogenous metabolic activation system of mammalian microsomal enzymes derived from Aroclor 1254-induced rat liver. The tester strains used in the assays were TA98 and TA100. A minimum of five dose levels of each test article or extract along with appropriate vehicle and positive controls were plated with tester strains TA98 and TA100 in the presence and absence of rat liver S9 activation. All dose levels of test article, vehicle controls, and positive controls were plated in duplicate.

4.5 Developmental Toxicity Test

Five bimonthly developmental toxicity tests were conducted at pH 4 and 7 using the frog embryo teratogenesis assay - Xenopus (FETAX). The assay is a 96-h quantitative developmental assay used to screen for developmental toxicants in aquatic media. The assays were conducted using the static renewal (solutions renewed every 24 h) test method Designation E 1439-91 of the American Society for Testing and Materials (ASTM, 1992). Embryolethality and malformations were determined; growth retardation was not evaluated. The identification and interpretation of malformations in the embryos at 96 h were made via the atlas of Bantle et al. (1991). Aliquots of the same groundwater used for the acute and short-term chronic toxicity biomonitoring tests were used for the FETAX assays. In addition to the standard assay with groundwater, a 100% APG-EA tap water sample was run concurrently with each assay to provide supporting toxicological data for the APG-EA tap water being used in the chronic histopathology exposures (Section 4.6).

Embryos between normal stage 8 blastulae and normal stage 11 gastrulae were obtained from X. laevis breeding colonies at the UMD/WREC as described below. The embryos were de-jellied in a 2% L-cysteine solution (2 g of L-cysteine per 98 mL of FETAX solution). Once de-jellied, the embryos were rinsed and re-suspended in FETAX solution (ASTM, 1992). The embryos were tested in glass petri dishes containing 10 mL of solution. Two replicates of 25 embryos/replicate were used for each test treatment. The tests were conducted at 24 ± 0.2°C under a 16-h light: 8-h dark photoperiod (fluorescent lights; ≈75 foot candles at the surface of the test medium) in a constant temperature

environmental chamber.

The UMD/WREC X. laevis adult colony was maintained in flow-through (≈4 replacement volumes per day) circular polyethylene aquaria (0.91 m I.D. x 0.36 m high) with a water depth of 10 cm. Each aquarium contained a maximum of 10 adults. UMD/WREC non-chlorinated deep well water (water quality given in Section 4.3.3) held at 23.5 ± 0.5 °C served as the culture medium. All frogs were fed every 5-6 d with commercial beef liver supplemented with liquid vitamins (PolyViSol; Mead-Johnson Nutritionals, Evansville, IN). The colony was held under a photoperiod of 16 h light:8 h dark. Mating pairs were bred in the dark in 23.5 ± 0.5 °C UMD/WREC non-chlorinated water at ≈70 d intervals by injecting 400 and 800 I.U. of human chorionic gonadotropin (HCG) in the dorsal lymph sac of the males and females, respectively. Amplexus occurred 4-6 h after injecting HCG; egg deposition occurred 9-12 h following HCG injection. The original breeding stock was obtained from Xenopus I (Ann Arbor, MI).

4.6 Chronic Growth and Histopathology Test

Chronic histopathologic changes were evaluated using the Japanese medaka (O. latipes) as the experimental model. The Japanese medaka is a sensitive laboratory model for screening environmental pollutants which may induce histopathological changes and neoplasms (for ex., see Hawkins et al., 1995; Metcalfe, 1989; Powers, 1989). Both unexposed and fry exposed to diethylnitrosamine (DEN) were exposed continually under flow-through test conditions for a 9-month period. A subset of organisms was taken after 6 months of exposure for morphometric measurements and histopathological evaluation. The CEHR test designation was Protocol No. 401-002R (USACEHR, 1994a).

Fish were exposed in two separate assay systems to three dilutions of groundwater plus control diluent water using APG-EA tap water and West Branch of Canal Creek water as the diluent water. The two test systems were designated as the APG-EA test system and West Branch of Canal Creek test system. The fish were exposed to the following dilutions in both the APG-EA and West Branch of Canal Creek test systems: 25% groundwater by volume, 5% groundwater by volume, 1% groundwater by volume, and diluent water (APG-EA or West Branch of Canal Creek water). A 100% groundwater treatment could not be used because the pH of the groundwater was ≈4 which would have caused excessive mortality over the 9-month exposure period. Consideration was given to buffering the 100% groundwater to pH 7 and conducting the 100% treatment at pH 7. However, a preliminary evaluation of low pH groundwater buffered to pH 7 showed that excessive precipitation of metals occurred (Burton et al., 1994). Thus, 100% groundwater was not buffered to pH 7 and used as an experimental treatment. Additional control fish were also held at CEHR (see below).

The flow-through test solutions in both the APG-EA and West Branch of Canal Creek test systems were delivered by solenoid-activated proportional dilutor systems which were constructed primarily of glass and stainless steel; some silicon tubing was also used. The test concentrations in each test system were delivered to sixteen 19 L (5 gal) glass aquaria (4 aquaria at 25% groundwater by volume; 4 at 5% groundwater by volume; 4 at 1% groundwater by volume; and 4 control aquaria); each aquarium contained a volume of ≈16 L (4.25 gal). The study protocol required that all aquaria be held at 25 ± 2°C in constant temperature water baths. The APG-EA and West Branch of Canal Creek dilutors were calibrated to complete one full cycle every 3 ± 0.8 min. During a cycle, each tank received 300 ± 15 mL of solution.

Both unexposed fry and fry exposed to DEN, were reared off-site at CEHR until 16 d old. The DEN-initiated fish were exposed to 10 mg/L DEN for 48 h when the organisms were 13 d old. Prior to the start of the exposure to groundwater, the 16-d old fish were randomized into 8 groups of 60 fish/group for both the unexposed and DEN-initiated groups for both the APG-EA and West Branch of Canal Creek test systems. The fish were suspended in 1-L mesh-bottom glass beakers in the appropriate flow-through test aquaria in the biomonitoring laboratory. The fish were held in the beakers for one week after which they were released into the aquaria. Two replicates of both DEN-initiated and fish not initiated were held at CEHR for 9 months as additional controls.

Japanese medaka, 16-22 d old, were fed microworms two feedings per day and live brine shrimp (Artemia sp.) (<24 h old) two feedings per day (≈30 brine shrimp/fish). Pre-adult fish, 23-30 d old, were fed Tetramin® flake food two feedings per day and live brine shrimp <24 h old (one feeding per day; ≈40 brine shrimp per fish). Adult fish, >30 d old, were fed Tetramin® flake food (three feedings per day on Tuesday and Thursday and two feedings per day on the remaining days) and live brine shrimp (one feeding per day on Monday, Wednesday, and Friday). The ration was adjusted as the size of the fish increased. Tanks were cleaned on an as needed basis (usually 1-2 times a week) by scrubbing algae from the sides of the tanks, allowing the debris to settle, and then siphoning. Tetramin® was fed ad libitum for 15-30 min during each feeding.

The number of test organisms alive in each tank were monitored and recorded daily. Moribund fish were euthanized and fixed in Bouin's solution for subsequent histological observation. The dilutor cycle times were calculated and recorded daily. The volume of groundwater and diluent water delivered to the aquaria was checked weekly. When necessary, cycle time and/or volume distributions were adjusted. The dilutors were occasionally shutdown (for no more than one hour) and cleaned on an as needed basis. Daily water quality (DO, pH,

and temperature) was determined in all aquaria. Additional water quality tests (alkalinity, hardness, conductivity, total residual chlorine, free available chlorine, and total ammonia-nitrogen) were performed once a week in all aquaria (Section 4.7.2). A 16-h light:8-h dark photoperiod (fluorescent lights at 70-100 foot candles) was maintained throughout the study. Unionized ammonia-nitrogen was determined by the method of Thurston et al. (1979). Comprehensive chemical analyses were performed five times at bimonthly intervals as discussed in Section 4.7.1 on 100% groundwater, 100% APG-EA tap water, 100% West Branch of Canal Creek water and on water taken from each test system at 25, 5, and 1% groundwater by volume during the test periods shown in Table 1.

A major deviation from the study protocol was made after 6 months of exposure in the West Branch of Canal Creek test system. The water supply lines (both the primary and backup lines) from West Branch of Canal Creek to the biomonitoring trailer froze repeatedly during severe cold weather in late December through early February. The lost of water occurred because northeast winds blew the water out of the creek which subsequently shut down the water supply pump and caused the water to freeze in the water supply lines. During the periods when no West Branch of Canal Creek water was available, APG-EA tap water was used as an alternative diluent water for the West Branch of Canal Creek test system. Because of the frequent lost of West Branch of Canal Creek water (several days at a time), a decision was made at the end of the 6-month exposure period (February 5, 1995), to discontinue the use of West Branch of Canal Creek water. APG-EA tap water was used as the diluent water in the West Branch of Canal Creek test system for the last 3 months of the 9-month exposure. Groundwater was still provided to all exposure aquaria during the last 3 months of the exposure.

On day 181, approximately 20 Japanese medaka from each tank in both the APG-EA and West Branch of Canal Creek test systems were removed and taken back to CEHR for fixation (Bouin's solution) and subsequent histological observation. Wet weight and standard length measurements were taken on all fish. The morphometric data were taken to assess the effects of a chronic 6-month exposure to the contaminated groundwater as well as the general health of the fish. On day 272, when the exposure was completed, the remaining Japanese medaka were also taken back to CEHR for morphometric measurements and subsequent histological analysis. The histological analyses of the 6- and 9-month exposures were conducted by Experimental Pathology Laboratories, Inc. (EPL), Herndon, VA. Morphometric and histological analyses were also conducted on the 6- and 9-month additional control fish held at CEHR.

4.7 Chemical Analyses

4.7.1 Comprehensive Chemical Analyses

Comprehensive chemical analyses were performed five times at bimonthly intervals on 100% groundwater, 100% APG-EA tap water (charcoal filtered), and 100% West Branch of Canal Creek water (mechanically filtered to ≈80 μ). In addition, 25, 5, and 1% groundwater by volume samples from both the APG-EA and West Branch of Canal Creek test systems were analyzed during the test periods shown in Table 1. As discussed in the previous section, the surface water supply to the West Branch of Canal Creek aquaria was discontinued on February 5, 1995 and replaced with APG-EA dechlorinated tap water. The water samples taken from the West Branch of Canal Creek aquaria on March 23, 1995 and May 2, 1995 were labeled as West Branch of Canal Creek samples to prevent them from being confused with water samples taken from the APG-EA aquaria.

The comprehensive chemical analyses included general water quality, metals, priority pollutant volatile organics, priority pollutant base neutrals, priority pollutant acid extractables, organophosphorus pesticides, chlorinated pesticides, chlorinated herbicides, and munitions. The elements and/or compounds analyzed in each group are presented in the data tables discussed in Section 5.6.1. The 100% groundwater samples and 100% West Branch of Canal Creek sample Nos. 1, 2, and 3 (Table 1) were grab samples taken directly from the fed lines to the biomonitoring trailer. West Branch of Canal Creek (100%) sample Nos. 4 and 5 were grab samples taken directly from the creek. The 25, 5, and 1% groundwater by volume samples from both the APG-EA and West Branch of Canal Creek test systems were composite samples taken from the four replicate treatment tanks in the chronic histopathology study (Section 4.6). Grab samples of 100% APG-EA tap water were taken from a large polypropylene tank with a 99% particle replacement time of ≈12 h.

The water samples were placed in appropriate containers provided by the vendor for the various analyses. The containers were placed on ice and picked up by the vendor on the morning the samples were taken for the analyses. The comprehensive chemical analyses of all materials with the exception of the munitions were performed by Johnston Spectra Laboratories, Mechanicsburg, PA. The methods used for the analyses of all materials are given in the data tables discussed in Section 5.6.1. The five munitions samples were analyzed by CEHR via in-house procedures (USACEHR, 1993).

4.7.2 Routine Water Quality Analyses

Routine water quality was measured in all histopathology treatment tanks. Dissolved oxygen, pH, and temperature were

measured daily. Alkalinity, hardness, conductivity, total residual chlorine, free available chlorine, and total ammonia-nitrogen were measured once a week (all tests were performed on the same days). Unionized ammonia-nitrogen was determined by the method of Thurston et al. (1979). The methods used for the analyses followed the procedures given in Standard Methods (APHA et al., 1992).

In addition to the temperature measurements made in the aquaria during the chronic histopathology test, temperature was monitored continuously in one control tank of both the APG-EA and West Branch of Canal Creek test systems via a strip chart recorder (Cole-Palmer Thermistor Recorder Model No. 08354-15, Cole-Palmer Instrument Co., Chicago, IL).

4.8 Test Endpoints and Data Analyses

The test endpoint for the Microtox® 5- and 15-min EC50s was a reduction in bioluminescence. The EC50s and their 95% fiducial limits were determined by probit analysis using the software program supplied by Microtox® (Microtox®, 1988). The test endpoint for the acute effects of groundwater to the green alga was growth, measured as density (cells/mL). The 96-h EC50s for growth were estimated by using the "inhibition proportion" technique recommended by Horning and Weber (1985). The technique uses quantal analyses (e.g., probit or moving average angle methods) to estimate EC50s and their 95% fiducial or confidence limits. Since the assumptions of the quantal analysis are not met in the classical sense because of the very nature of the growth data, the count data at each treatment were averaged and subsequently converted to "inhibition proportions" using the formula below before a moving average angle analysis was performed (Stephan, 1978).

$$I = C - T / C * 100$$

where: C = the mean growth of the controls
T = the mean growth at a given treatment

The 96-h EC50s and their 95% confidence limits for embryo malformations in the FETAX assays were determined by the moving average angle method using an EPA statistical program (Stephan, 1978). The test endpoint for all 96-h Japanese medaka tests, 48-h and 7-d LC50 tests with cladocerans, and 96-h and 7-d LC50 tests with fathead minnows was mortality. The LC50s and their 95% confidence limits were determined by the moving average angle method when toxicity >50% occurred (Stephan, 1978).

The test endpoint for the chronic toxicity of groundwater at pH 4 and 7 to the green alga was growth measured as density (cells/mL). The no-observed-effect concentrations (NOEC) and lowest-observed-effect concentrations (LOEC) were determined by

Dunnett's test. Dunnett's test consists of an analysis of variance (ANOVA) to determine the error term, which is then used in a multiple comparison test for comparing each of the treatment means with the control mean. The assumptions upon which the use of Dunnett's test are contingent are that the observations within treatments are independent and normally distributed, with homogeneity of variance. The chi-square test for normality and Bartlett's test for homogeneity of variances were performed before the Dunnett's test was used. The above statistical tests were performed using Toxstat (Gulley et al., 1989) at a minimum probability level of 0.05.

The endpoints for the 7-d survival and reproduction tests with Ceriodaphnia were survival and young production. The endpoints for the fathead minnow 7-d survival and growth tests were survival and growth. The endpoints for the 96-h FETAX assay were survival and number of malformations. The statistics used for the LC50 data and FETAX EC50 (malformations) data are given above. NOECs and LOECs were determined as follows. The adult raw cladoceran survival data were analyzed by Fisher's Exact test. Arc-sine square root transformations were made on the FETAX percent embryo survival and percent embryo malformation data as well as the fathead minnow percent survival raw data before further data analyses were performed. With the exception of the cladoceran survival data, all data were then subjected to a chi-square test of normality and Bartlett's test for homogeneity of variance.

When the data sets met the assumptions of normality and homogeneity of variance, a parametric statistic was used. Dunnett's test was used when the number of replicates was constant among treatments. A t-test with Bonferroni adjustment of error rate was performed when the number of replicates was not constant among treatments. When a data set failed to meet the assumptions of normality or homogeneity of variance, a nonparametric statistic was used. Steel's Many-One Rank test was performed when equal number of replicates were used. The statistical tests were performed using Toxstat (Gulley et al., 1989). A minimum probability level of 0.05 was used for all tests.

The morphometric endpoints for the Japanese medaka chronic growth and histopathology study after 6 and 9 months of exposure were wet weight and standard length. The analyses of the 6- and 9-month wet weight and standard length data were conducted as a split plot ANOVA using a general linear model type III test (SAS, 1989). The whole plots were tanks which were in turn split into subplots by fish sex. The whole plot treatments that were applied to separate tanks and thus were tested against the among tank error were 1) diluent water (APG-EA tap water and West Branch of Canal Creek water); 2) DEN (DEN-initiated and no DEN-initiated); and 3) concentration (0, 1, 5, and 25% groundwater by

volume). The sex (male vs. female) split plot factor that occurred within each tank was tested against the within tank error term. The three whole plot factors and all their interactions were tested at the whole plot level. The split plot factor and all its interactions with whole plot factors were tested against the within plot error. Wet weight and standard length at 6 and 9 months for the control fish held at CEHR vs. the APG-EA control fish were analyzed by linear contrast within the split plot analysis.

The raw data were checked at the whole plot level for normality and homogeneity of variance by the Shapiro Wilks test and Levene's test, respectively. The split plot data were also checked for normality by the Shapiro Wilks test. A test for homogeneous variance was not possible for the split plot residuals because only two residuals were present for each treatment. A minimum probability level of 0.05 was used for all tests. The histopathology data enumerated by Experimental Pathology Laboratory, Inc. at 6 and 9 months were not treated statistically.

SECTION 5

RESULTS AND DISCUSSION

The Results and Discussion Section is organized as follows. The results and discussion for all of the biomonitoring systems are presented in separate sections for each test system. The endpoints/responses for each biomonitoring toxicity test are summarized in Table 2. The table is organized as Tests Nos. 1, 2, 3, 4, and 5 which reflect the bimonthly test design. The Microtox® and Japanese medaka chronic histopathology and morphometric results are presented under the Test No. 1 column for space convenience purposes only; the tests were not bimonthly tests as the heading implies. With the exception of the comprehensive analytical chemistry data, all raw data, water quality data, and statistical analyses for the biomonitoring test systems are given in the report by Burton et al. (1995).

5.1 Acute Toxicity Tests

5.1.1 Microtox®

A summary of the Microtox® 5- and 15-min EC50 (reduction of bioluminescence) results is given in Table 2. The Microtox® 5- and 15-min EC50s for 100% groundwater at pH 4 ranged from 18.7-70.9 and 31.9-88.4% groundwater by volume, respectively. Less toxicity was observed in the 15-min EC50s relative to the 5-min EC50s. Toxicity was also determined in 100% groundwater samples buffered to pH 7. Only one sample of 100% groundwater buffered to a pH of 7 exhibited toxicity. The 5- and 15-min EC50s for the sample were 55.6 and 48.6% groundwater by volume, respectively. The raw groundwater was much less toxic at pH 7 than at pH 4.

No toxicity was detected in any raw West Branch of Canal Creek water samples (Table 2). No toxicity was detected in any samples taken from the 25, 5, and 1% groundwater by volume histopathology tanks diluted with APG-EA tap water. Likewise, no toxicity was found in any samples taken from the 25, 5, and 1% groundwater by volume West Branch of Canal Creek histopathology tanks.

The toxicity of the raw groundwater as shown by the Microtox® assay is not surprising when one considers the complex mixture of the contaminants in the groundwater (Section 5.6.1; Table 3). For example, the 5-min EC50s for both copper and zinc are less than the groundwater concentrations shown in Table 3 (Qureshi et al., 1982; Elnabarawy et al., 1988); the 15-min EC50s for cobalt, copper and zinc are less than the concentrations shown in Table 3 (Elnabarawy et al., 1988). Similarly, several volatile chlorinated organics have been shown to be toxic via the 5- and/or 15-min Microtox® analysis (Kaiser and Ribo, 1988).

TABLE 2. SUMMARY OF THE TOXICITY ENDPOINTS/RESPONSES FOR BIOMONITORING TESTS CONDUCTED ON CANAL CREEK GROUNDWATER (WELL CC-27B) FROM AUGUST 12, 1994 TO MAY 10, 1995[a]

Bioassay	Endpoint	Value[b]				
		Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Microtox®:						
100% (pH 4)	5-min EC50[c]	19-71[d]	N/A	N/A	N/A	N/A
100% (pH 4)	15-min EC50[c]	32-88[e]	N/A	N/A	N/A	N/A
100% (pH 7)	5-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
100% (pH 7)	15-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
25% APG H_2O	5-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
25% APG H_2O	15-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
5% APG H_2O	5-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
5% APG H_2O	15-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
1% APG H_2O	5-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
1% APG H_2O	15-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
25% WB H_2O	5-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
25% WB H_2O	15-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
5% WB H_2O	5-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
5% WB H_2O	15-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
1% WB H_2O	5-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
1% WB H_2O	15-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
100% APG H_2O	5-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
100% APG H_2O	15-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
100% WB H_2O	5-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A
100% WB H_2O	15-min EC50[c]	Not toxic	N/A	N/A	N/A	N/A

TABLE 2. (CONTINUED)

Bioassay	Endpoint	Value[b]				
		Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Green alga:						
pH 4	96-h EC50[f]	57 (54.5-59.5)	52 (48.6-55.6)	56 (47.2-67.4)	51 (47.7-55.3)	48 (44.6-51.0)
pH 4	NOEC[f]	10	10	18	10	18
pH 4	LOEC[f]	18	18	32	18	32
pH 7	96-h EC50[f]	80 (62.5-111.8)	67 (59.9-77.1)	78 (50.1-111.1)	67 (59.4-78.8)	96 (81.5-124.6)
pH 7	NOEC[f]	10	10	18	18	18
pH 7	LOEC[f]	18	18	32	32	32
Cladoceran:						
pH 4	48-h LC50	65 (57.2-75.5)	65 (57.2-75.5)	65 (57.2-75.5)	65 (57.2-75.5)	65 (62.5-67.1)
pH 4	7-d LC50	65 (57.2-75.5)	65 (57.2-75.5)	63 (55.0-73.7)	59 (50.0-69.7)	62 (59.7-64.4)
pH 4	NOEC[g]	10	10	18	10	10
pH 4	LOEC[g]	18	18	32	18	18
pH 7	48-h LC50	Not toxic	Not toxic	Not toxic	Not toxic	Not toxic
pH 7	7-d LC50	56 (47.1-67.4)	66 (52.9-97.6)	38 (27.8-49.0)	38 (29.9-48.0)	74 (69.5-79.2)
pH 7	NOEC[g]	10	10	10	10	18
pH 7	LOEC[g]	18	18	18	18	32

TABLE 2. (CONTINUED)

Bioassay	Endpoint	Value[b]				
		Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Fathead minnow:						
pH 4	96-h LC50	46 (41.6-51.3)	60 (56.7-64.7)	39 (35.9-41.7)	54 (50.3-57.7)	50 (45.4-55.6)
pH 4	7-d LC50	42 (37.9-46.7)	45 (40.3-50.3)	32 (28.8-36.0)	44 (39.9-49.1)	47 (42.8-52.2)
pH 4	NOEC[h]	18	32	18	32	32
pH 4	LOEC[h]	32	56	32	56	56
pH 7	96-h LC50	Not toxic	Not toxic	Not toxic	Not toxic	Not toxic
pH 7	7-d LC50	Not toxic	Not toxic	Not toxic	Not toxic	Not toxic
pH 7	NOEC	Not toxic	Not toxic	Not toxic	Not toxic	Not toxic
pH 7	LOEC	Not toxic	Not toxic	Not toxic	Not toxic	Not toxic
Japanese medaka:						
pH 4	96-h LC50	78 (66.7-102.3)	63 (55.4-71.7)	68 (60.9-78.1)	63 (55.0-73.7)	94 (84.6-107.2)
pH 7	96-h LC50	Not toxic	Not toxic	Not toxic	Not toxic	Not toxic
West Branch	96-h LC50	Not toxic	Not toxic	Not toxic	Not toxic	Not toxic

TABLE 2. (CONTINUED)

Bioassay	Endpoint	Value[b]				
		Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Ames:						
Groundwater	Mutagenicity	Negative	Negative	Negative	Negative	[i]
Groundwater (100X)	Mutagenicity	Negative	Negative	Negative	Negative	Negative
West Branch	Mutagenicity	Negative	Negative	Negative	Negative	[i]
West Branch (100X)	Mutagenicity	Negative	Negative	Negative	Negative	Negative
APG-EA H_2O	Mutagenicity	Negative	[i]	[i]	[i]	[i]
APG-EA H_2O (100X)	Mutagenicity	Negative	[i]	[i]	[i]	Negative
FETAX:						
pH 4	4-d LC50	No LC50	No LC50	No LC50	No LC50	Not toxic
pH 4	4-d EC50[j]	No EC50	90 (69.5-183.6)	No EC50	78 (53.1-6698.2)	No EC50
pH 4	NOEC[k]	18	10	10	10	10
pH 4	LOEC[k]	32	18	18	18	18
pH 7	4-d LC50	Not toxic	No LC50	Not toxic	No LC50	Not toxic
pH 7	4-d EC50[j]	Not toxic	Not toxic	No EC50	No EC50	No EC50
pH 7	NOEC[k]	Not toxic	Not toxic	18	18	18
pH 7	LOEC[k]	Not toxic	Not toxic	32	32	32

TABLE 2. (CONTINUED)

Bioassay	Endpoint	Value[b]				
		Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Chronic growth and histopathology:						
6 months	Growth	Differences occurred[l]	N/A	N/A	N/A	N/A
6 months	Lesions	[m]	N/A	N/A	N/A	N/A
9 months	Growth	Differences occurred[l]	N/A	N/A	N/A	N/A
9 months	Lesions	[m]	N/A	N/A	N/A	N/A

[a] Test acceptability criteria were met in all tests in which criteria were specified as part of the test quality assurance (QA) practice.
[b] All endpoints are given as percent groundwater by volume.
[c] Range of all EC50s for reduction in bioluminescent activity conducted from August 12, 1994 to May 10, 1995.
[d] The 95% fiducial limits of the 5-min EC50s of 19 and 71 at pH 4 are 0.9-396.6 and 16.5-305.6, respectively.
[e] The 95% fiducial limits of the 15-min EC50s of 32 and 88 at pH 4 are 8.3-122.6 and 29.8-262.0, respectively.
[f] Test endpoint- reduction in growth (cell density).
[g] Test endpoint- reduction in neonate production.
[h] Test endpoint- reduction in growth (dry weight) for Test No. 1 at pH 4; the test endpoint for Test Nos. 2, 3, 4, and 5 at pH 4 was an increase in mortality rather than a reduction in growth.
[i] Assay not conducted.
[j] 96-h EC50 for malformations.
[k] Test endpoint- increased number of malformations for Test Nos. 1, 2, 3, 4, and 5 at pH 4 and Test Nos. 3 and 5 at pH 7; the test endpoint for Test No. 4 at pH 7 was an increase in mortality rather than an increase in malformations.

TABLE 2. (CONTINUED)

Bioassay	Endpoint	Value[b]				
		Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5

[l] A number of differences in both wet weight and standard length occurred. See Section 5.5.2 for further detail.
[m] See Section 5.5.3 for results.

TABLE 3. SUMMARY OF THE FIVE BIMONTHLY CHEMICAL ANALYSES (RANGE OF CONCENTRATIONS) CONDUCTED ON RAW CANAL CREEK GROUNDWATER (WELL CC-27B) FROM AUGUST 1994 TO MAY 1995 - GENERAL WATER QUALITY

Parameter	Concentration	Unit
Alkalinity	<1-4.0	mg/L as $CaCO_3$
Ammonia Nitrogen	0.011-0.055	mg/L as N
Bromide	<0.2	mg/L as Br
Chloride	74-147	mg/L as Cl
Cyanide	<0.002-<0.006	mg/L as Cn
Fluoride	0.241-0.349	mg/L as F
Hardness	58.0-66.4	mg/L as $CaCO_3$
pH	3.62-4.30	Std. Unit
Nitrate	1.59-2.87	mg/L as N
Nitrite	<0.001-<0.002	mg/L as N
Phosphate	0.151-1.32	mg/L as P
Specific Conductance @ 25 °C	336-441	µmhos/cm
Sulfate	92.0-119	mg/L as SO_4
Sulfite	<0.002-<0.02	mg/L as H_2S
Total Organic Carbon	<2.0-2.6	mg/L
Total Suspended Solids	<1.0-3.5	mg/L

TABLE 3. (CONTINUED) - METALS[a]

Parameter	Concentration	Unit
Aluminum	1660-2390	µg/L as Al
Antimony	<14.1-<50	µg/L as Sb
Arsenic	<3.2-<5	µg/L as As
Beryllium	<0.5-1.8	µg/L as Be
Boron	55.4-409	µg/L as B
Cadmium	<1.5-<5	µg/L as Cd
Calcium	15700-17600	µg/L as Ca
Chromium	<6-<10	µg/L as Cr
Cobalt	41.7-46.1	µg/L as Co
Copper	10.2-24.4	µg/L as Cu
Iron	5.5-34.5	µg/L as Fe
Lead	<14.5-<50	µg/L as Pb
Magnesium	5360-6390	µg/L as Mg
Manganese	639-848	µg/L as Mn
Mercury	<0.1-0.1	µg/L as Hg
Molybdenum	<28.9-52.8	µg/L as Mo
Nickel	22.2-26.7	µg/L as Ni
Potassium	2000-2750	µg/L as K
Selenium	<11.1-<50	µg/L as Se
Silver	<0.4-46.8	µg/L as Ag
Sodium	56900-62600	µg/L as Na
Thallium	<50-<75	µg/L as Ti
Tin	<9.7-<10	µg/L as Sn
Zinc	57.5-88.4	µg/L as Zn

TABLE 3. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS

Parameter	Concentration	Unit
Bromochloromethane	4.6-113.4	µg/L
Bromodichloromethane	0.78-97.9	µg/L
Carbon Tetrachloride	32.8-57.7	µg/L
Chloroform	54.0-103	µg/L
1,2-Dichlorobenzene	0.53[b]	µg/L
1,2-Dichloroethane	2.1-3.6	µg/L
cis-1,2-Dichloroethene	1.3-3.3	µg/L
1,1,2,2-Tetrachloroethane	53.8-75.9	µg/L
Tetrachloroethene	3.49-6.7	µg/L
1,2,4-Trichlorobenzene	0.6[b]	µg/L
1,1,1-Trichloroethane	4.6[b]	µg/L
1,1,2-Trichloroethane	0.7-1.08	µg/L
Trichloroethene	64.4-102.0	µg/L

[a] The metal concentrations are total metal; not dissolved metal.
[b] Compound found in only one of five samples.

Chloroform, 1,2-dichlorobenzene, 1,2-dichloroethane, tetrachloroethane, 1,2,4-trichlorobenzene, and 1,1,1-trichloroethane all have 5- and/or 15-min EC50s below the concentrations found in the groundwater (Curtis et al., 1982; McFeters et al., 1985; Qureshi et al, 1982; Ribo and Kaiser, 1983).

With the execption of one sample, no acute toxicity was observed via Microtox® when the groundwater was buffered to pH 7. The reason for the elimination of acute toxicity at pH 7 is not clear. One may speculate that the reduction and/or elimination of toxicity at pH 7 may be related to the heavy metals as they shift from a divalent cation at pH 4 to less toxic species at pH 7 (Lee, 1973); however, there is no evidence that this mechanism is appropriate for the Microtox® reaction.

5.1.2 Green Alga, Cladoceran, Fathead Minnow, and Japanese Medaka

The 96-h EC50s (reduction in growth) for the green alga exposed to raw groundwater at pH 4 and buffered groundwater at pH 7 are given in Table 2. The 96-h EC50s for reduction in growth at pH 4 ranged from 48-57% groundwater by volume (Table 2). The 96-h EC50s in the groundwater buffered to pH 7 ranged from 67-96% groundwater by volume.

Aluminum and silver have been show to be toxic to S. capricornutum at concentrations found in the groundwater. The 4-d EC50s (biomass) for aluminum (Al species not specified) range from 460-570 µg/L (U.S. EPA, 1988) which are well below the range of 1660-2390 µg/L found in the groundwater (Table 3). The 4-d EC50 (effect parameter not given) for silver has been reported to be 2.6 µg/L (unpublished data as cited in U.S. EPA, 1987). Few data are available on the possible joint toxicity of heavy metals to green algae (Faust et al., 1994). The groundwater at pH 7 appeared to be slightly less toxic than the groundwater at pH 4 (Table 2); however, the data were not treated statistically. It is difficult to speculate about possible differences in acute toxicity at pH 4 and 7 because the chemistry of aluminum and silver as a function of pH is not well understood (U.S. EPA 1987 and 1988). No single priority pollutant organic for which there are toxicity data can account for the toxicity observed in the alga (U.S. EPA, 1986b).

The 48-h acute LC50 toxicity data for the cladoceran at pH 4 and 7 are summarized in Table 2. Groundwater at pH 4 was acutely toxic to the cladoceran. The 48-h LC50 was 65% groundwater by volume for all five tests. Buffered groundwater was not acutely toxic to the cladoceran in any of the five tests after a 48-h exposure.

The 96-h LC50 data for the fathead minnow at pH 4 and 7 are summarized in Table 2. Groundwater at pH 4 was acutely toxic to the fathead minnow. The 96-h LC50s ranged from 39-60% groundwater by volume for the five tests. Buffered groundwater at pH 7 was not toxic in any test after a 96-h exposure.

The 96-h LC50 data for the Japanese medaka at pH 4 and 7 are also summarized in Table 2. Groundwater at pH 4 was acutely toxic to the Japanese medaka. The 96-h LC50s ranged from 63-94% groundwater by volume for the five tests. Buffered groundwater at pH 7 was not toxic in any test after a 96-h exposure. No toxicity occurred to Japanese medaka exposed to West Branch of Canal Creek water for 96 h.

The acute toxicity of the groundwater to the cladoceran, fathead minnow, and Japanese medaka at pH 4 may be attributable to the heavy metals in the groundwater (Table 3). Several EPA priority pollutant heavy metals (aluminum, copper, nickel,

silver, and zinc) were found in the groundwater. The concentration of copper and silver (when adjusted for water hardness) in the groundwater exceeded in some cases the EPA acute numerical water quality criterion of 18 and 4.1 µg/L, respectively, for freshwater organisms (U.S. EPA, 1984a; U.S. EPA, 1987). Furthermore, metals such as copper and zinc exist primarily as divalent cations at a pH of 4 which is the most toxic form of the metal (Lee, 1973; Sprague, 1985). It is well established that the toxicity of metals in chemical mixtures is additive for many aquatic animals (Marking, 1985). It is likely that the toxicity observed in the study may have been additive or greater than additive (de March, 1988). The elimination of acute toxicity at pH 7 for the cladoceran, fathead minnow, and Japanese medaka is most likely related to the reduction in toxicity of heavy metals as they shift from a divalent cation at pH 4 to less toxic species at pH 7 (Lee, 1973). The possibility that low pH per se may also play a role in the toxicity observed at pH 4 should also be considered since no toxicity occurred at pH 7. EPA acute (or chronic) numerical water quality criteria are not available for any of the organics present in the groundwater (U.S. EPA, 1986b).

5.2 Short-term Chronic Toxicity Tests

5.2.1 Green Alga

The NOECs and LOECs (reduction in cell density) for the green alga exposed to groundwater at pH 4 and 7 are summarized in Table 2. The test data and statistical analyses for Test Nos. 1-5 are given in Appendices 3-12. At pH 4, the NOECs for the five tests ranged from 10-18% groundwater by volume. The LOECs ranged from 18-32% groundwater by volume. At pH 7, the NOECs and LOECs, respectively, ranged from 10-18 and 18-32% groundwater by volume. With the exception of Test No. 4, the NOECs and LOECs were exactly the same at pH 4 and 7 for the same test period. The NOECs and LOECs were less at pH 7 than at pH 4 in Test No. 4 only. Thus, with the exception of one test, no difference in algal toxicity was found for groundwater at pH 4 and pH 7. As stated above in Section 5.1.2, it is difficult to speculate about the toxicity of aluminum and silver as a function of pH because the chemistry of aluminum and silver as a function of pH is not well understood (U.S. EPA 1987 and 1988).

5.2.2 Cladoceran

The 7-d LC50s, NOECs, and LOECs for the cladoceran exposed to groundwater at pH 4 and 7 are summarized in Table 2. The groundwater at pH 4 and 7 was toxic in all tests. The short-term chronic 7-d LC50s at pH 4 ranged from 59-65% groundwater by volume. The 7-d LC50s at pH 7 ranged from 38-74% groundwater by volume. The groundwater appeared to be more toxic at pH 7 than pH 4 in Test Nos. 3 and 4; no statistical analysis was conducted to determine significant differences. The 7-d LC50s at pH 7 in

Tests Nos. 3 and 4 were 38% groundwater by volume in contrast to 59 and 63% groundwater by volume at pH 4.

The NOECs (reduction in neonate production) at pH 4 ranged from 10-18% groundwater by volume while the LOECs ranged from 18-32% groundwater by volume in the five tests. Similarly, the NOECs (reduction in neonate production) at pH 7 ranged from 10-18% groundwater by volume while the LOECs ranged from 18-32% groundwater by volume in the five tests. The NOECs and LOECs were essentially the same at pH 4 and pH 7.

5.2.3 Fathead Minnow

The 7-d LC50s, NOECs, and LOECs for the fathead minnow exposed to groundwater at pH 4 and 7 are summarized in Table 2. The groundwater at pH 4 was toxic in all tests. The short-term chronic 7-d LC50s at pH 4 ranged from 32-47% groundwater by volume. The NOECs at pH 4 ranged from 18-32% groundwater by volume while the LOECs ranged from 32-56% groundwater by volume in the five tests. The NOEC and LOEC endpoints at pH 4 were a reduction in growth for Test No. 1 and an increase in mortality in Test Nos. 2-5. The groundwater was not toxic when buffered to pH 7.

The chronic toxicity observed for the cladoceran and fathead minnow may be related to several heavy metals (Table 3). As discussed below in Section 5.6.1, copper, mercury, and silver concentrations in the groundwater exceeded in one or more tests the EPA freshwater chronic numerical water quality criteria of 12 µg/L for copper (U.S. EPA, 1984a), 0.012 µg/L for mercury, and the proposed criterion of 0.92 µg/L for silver (U.S. EPA, 1987). The criteria for copper and silver are hardness dependent criteria; 100 mg/L as $CaCO_3$ used.

None of the priority pollutant organics found in the groundwater currently have numerical water quality criteria values because insufficient data exist to develop criteria (Potts, 1994). The lowest observed effect levels (LOEL) are given in the EPA water quality criteria for several of the organics (chloroform, 1,2-dichlorobenzene, 1,1,2,2-tetrachloroethane, and 1,1,2-trichloroethane); however, all of the LOELs are one or more orders of magnitude higher than the concentrations found in the groundwater. Thus, it is not clear what role, if any, additive toxicity from the metals and organics present in the groundwater may play in the chronic toxicity observed in the cladoceran and fathead minnow.

In contrast to the general reduction in acute toxicity when the cladoceran was tested in buffered groundwater, the chronic toxicity NOEC and LOEC values for the cladoceran were essentially the same at pH 4 and 7 (Table 2). Thus, the suggestion above that toxicity attributable to heavy metals is reduced at the higher pH does not appear to be valid for the cladoceran in the

chronic tests. The reason for this observation is not clear. Similar toxicity responses at pH 4 and 7 indicate that the effect of low pH per se is not important.

Buffered groundwater was not toxic to fathead minnow (Table 2). The elimination of chronic toxicity at pH 7 for the fathead minnow is most likely related to the reduction in toxicity of heavy metals as they shift from a divalent cation at pH 4 to less toxic species at pH 7 (Lee, 1973). However, one should not categorically rule out the possibility that the low pH per se may also account for some of the toxicity observed at pH 4 since no toxic occurred at pH 7.

5.3 Genotoxicity Tests

The results of the Ames mutagenicity assays are summarized in Table 2. Both unconcentrated and concentrated (100X) Ames assays were conducted on raw groundwater and West Branch of Canal Creek water in Test Nos. 1-4; assays on the concentrated fractions only were conducted in Test No. 5. Ames assays were conducted on both unconcentrated and concentrated (100X) APG-EA tap water samples in Test No. 1; only the concentrated sample was assayed in Test No. 5.

All unconcentrated and concentrated (100X) assays of groundwater, West Branch of Canal Creek water, and APG-EA tap water were found to be non-mutagenic (negative) with tester strains TA98 and TA100 in both the presence and absence of an exogenous metabolic activation system of mammalian microsomal enzymes derived from Aroclor-induced rat liver (S9 mix). Of the groundwater contaminants listed in Table 3, carbon tetrachloride, 1,2-dichloroethane, and trichloroethene have been reported to be chemical mutagens (Forum for Scientific Excellence, Inc., 1990). The lack of mutagenic activity in the groundwater concentrated 100X suggests that the concentrations of the mutagens are too low to induce significant mutations in the Ames assay (Hoffmann, 1991; Shugart, 1995).

5.4 Developmental Toxicity Test

The 4-d LC50, 4-d EC50 (malformations), NOEC, and LOEC results for the FETAX assays conducted in groundwater at pH 4 and 7 are summarized in Table 2. Little embryolethality occurred in the groundwater at pH 4 or 7 (Table 2). Some toxicity occurred in Test Nos. 1-4 at pH 4; however, no LC50s could be calculated because <50% mortality occurred. The raw groundwater was not toxic to the embryos at pH 4 in Test No. 5. The buffered groundwater was not toxic in three of the five tests. Some mortality occurred in Test Nos. 2 and 4; however, LC50s could not be calculated.

Significant ($\alpha = 0.05$) embryo malformations occurred in all of the raw groundwater assays; malformations also occurred in

three of the five assays at pH 7. Ninety-six-hour EC50s (malformations) of 90 and 80% groundwater by volume were obtained in Test Nos. 2 and 3 at pH 4; 96-h EC50s could not be calculated for any of the other tests at pH 4 or 7. The NOECs and LOECs (malformations) for the five groundwater assays at pH 4 were 10 and 18% groundwater by volume, respectively, in Test Nos. 2-5 and 18 and 32% groundwater by volume in Test No. 1. The NOECs and LOECs for Test Nos. 3, 4, and 5 at pH 7 were all 18 and 32% groundwater by volume, respectively. The test endpoint for Test No. 4 at pH 7 was an increase in mortality rather than malformations. The buffered groundwater was not toxic in Test Nos. 1 and 2. The buffered groundwater was less toxic than the raw groundwater in all assays where toxicity occurred.

A total of 308 malformations were observed in the embryos exposed to raw groundwater. The types of malformed embryos (as described by Bantle et al., 1991) after 96 h of exposure in raw groundwater were primarily multiple edema (≈32% of total malformations), coiled guts (≈26%), notochord (≈18%) and facial (≈12%). Severe (≈6%), cardiac edema (≈3%), abdominal edema (≈2%), eye (<1%), brain (<1%), and cardiac (<1%) were also observed in <14% of the total malformations. Fewer malformations were observed in the buffered groundwater tests (221 malformations); however, the same types of malformations that occurred in the raw groundwater were observed in the buffered groundwater assays. The most frequent malformations observed in buffered groundwater included coiled guts (≈46%), multiple edema (≈29%), and notochord (≈10%). Severe (≈7%), facial (≈5%), cardiac edema (≈2%), and abdominal edema (≈2%) were observed in <16% of the total malformations. The incidence of malformations were generally greater at the higher test concentrations in both the raw and buffered groundwater.

The developmental toxicity found in the FETAX assays is most likely related to the heavy metals present in the groundwater. Several heavy metals, including copper, cadmium, and zinc, have been shown to cause developmental problems in lower vertebrate aquatic organisms (Weis and Weis, 1989). Dawson et al. (1985) found that mixtures of heavy metals (copper, cadmium, lead, and zinc) from acidic mine sources caused teratogenic effects and mortality when evaluated by FETAX. When the pH was adjusted from lows which ranged from 3.2 to 5.9 to pH 7, toxicity and teratogenicity decreased. The same response occurred in the present study. The possible role of the organics in the groundwater is not clear since FETAX data do not exist for the individual materials (Bantle, 1994 and 1995).

5.5 Chronic Growth and Histopathology Test

5.5.1 Mortality

The total number of fish that died at the end of 9 months in all treatments including the controls ranged from a low of 1.7%

to a high of 21.7%. The percent dead for all fish, including the controls, held in the APG-EA system ranged from 1.7 to 15.0%. The average mortality, including the controls, for all treatments in the APG-EA system was 9.1%. The percent mortality of all the fish held in the West Branch of Canal Creek system ranged from a low of 3.3% to a high of 21.7%. The average mortality, including the controls, for the West Branch of Canal Creek system was 13.5%. The mortality of the four CEHR control tanks ranged from 0 to 3.3%; the average was 2.5%.

To the authors knowledge, there are no test mortality acceptability criteria for a 9-month test. If one uses the mortality acceptability criteria for early life stage (ELS) toxicity tests which run for 1-2 months after hatch or fry swim-up, the mortality observed in this study falls within ELS acceptability criteria (Goodman, 1986). For example, the ELS test acceptability criteria for all eight freshwater species listed in the draft ASTM standard guide (Japanese medaka are not included in the guide) run from 60-75% (Goodman, 1986). That is, for a test to be acceptable, 60-75% of the control organisms must be alive at the end of the study depending on the species being studied. The percent survival of the Japanese medaka in all treatments, including the control and experimental fish, in both the APG-EA and West Branch of Canal Creek systems was greater than the draft ASTM ELS acceptability criteria for control fish.

5.5.2 Morphometric Analyses

No difference in wet weight at 6 months was found in the whole plot analysis of APG-EA diluent water vs. West Branch of Canal Creek water; DEN-initiated vs. fish not uninitiated; and APG-EA vs. West Branch of Canal Creek 0, 1, 5, and 25% groundwater by volume. A significant interaction ($\alpha = 0.0186$) for wet weight was found at 6 months in the split plot analysis of diluent water (APG-EA water vs. West branch of Canal Creek water) x sex (male vs. female). The males in APG-EA water were significantly ($\alpha = 0.0358$) larger than the males in West Branch of Canal Creek water. The females in West Branch of Canal Creek water were significantly ($\alpha = 0.0432$) larger than the males in the creek water.

A significant difference ($\alpha = 0.0001$) in standard length at 6 months was found between fish in APG-EA water vs. West Branch of Canal Creek water in the whole plot analysis. The APG-EA fish were longer than the West Branch of Canal Creek fish. The whole plot analysis also showed that a significant ($\alpha= 0.0053$) interaction occurred in the concentration x DEN treatments at 6 months for standard length. The control DEN-initiated fish were longer than the fish in all of the following treatments: control fish not initiated ($\alpha = 0.0009$); DEN-initiated fish in 1% groundwater by volume ($\alpha = 0.0061$); fish not initiated in 1% groundwater by volume ($\alpha = 0.0101$); DEN-initiated fish in 5% groundwater by volume ($\alpha = 0.0296$); DEN-initiated fish in 25%

groundwater by volume (α = 0.0017); and fish not initiated in 25% groundwater by volume (α = 0.0009).

In the split plot analysis of standard length at 6 months, there was marginal evidence (α = 0.0499) that a 3-way interaction of concentration x DEN x sex may be important. The interactions were caused primarily by two groups of females. With the exception of the DEN-initiated control males (α = 0.1284), the DEN-initiated control females were longer than the males and females in all DEN (DEN-initiated and fish not initiated) and concentration (0, 1, 5, and 25% groundwater by volume) groups. In contrast, the control females not initiated were shorter than the males and females in all groups with the exception of the DEN-initiated males in 1% groundwater by volume (α = 0.3847), males not initiated in 1% groundwater by volume (α = 0.0724) DEN-initiated females in 25% groundwater by volume (α = 0.4302), and the DEN-initiated males in 25% groundwater by volume (α = 0.0621).

The linear contrasts within the split plot analysis for the controls at the APG-EA test site vs. the controls held at CEHR showed that the fish held at APG-EA were significantly larger at 6 months in both weight wet (α = 0.0001) and standard length (α = 0.0001).

The following wet weight results were found at 9 months. The whole plot treatments showed that diluent water (APG-EA water vs. West Branch of Canal Creek water) and concentration (0, 1, 5, and 25% groundwater by volume) effects occurred. The fish held in APG-EA water were significantly (α = 0.0030) heavier than the fish held in West Branch of Canal Creek water. The concentration effect showed that the fish in 25% groundwater by volume were heavier than control fish (α = 0.0210) and fish held in 5% groundwater by volume (α = 0.0123) at the whole plot level.

The split plot analysis for wet weight at 9 months showed that four different interactions occurred with sex. 1) The females were significantly (α = 0.0001) larger than the males. 2) A diluent x sex interaction showed that the females in the APG-EA water were significantly larger than the males in APG-EA water (α = 0.0096) and males in West Branch of Canal Creek water (α = 0.0001). The females in West Branch of Canal Creek water were significantly larger (α = 0.0001) than the males in the creek water. The males in APG-EA water were larger than the males in creek water (α = 0.0001). 3) A DEN x sex interaction showed that DEN-initiated females were significantly heavier than DEN-initiated males (α = 0.0001), females not initiated (0.0305), and males not initiated (α = 0.0001). The females not initiated were larger than the DEN-initiated males (α = 0.0002) and males not initiated (α = 0.0017). 4) A 4-way interaction occurred with diluent water x concentration x DEN x sex. A number of statistically significant terms occurred which made the analysis difficult to interpret.

The whole plot analysis of standard length at 9 months showed that the APG-EA fish were significantly (α = 0.0028) longer than the West Branch of Canal Creek fish. Six sex interactions for standard length occurred at the split plot level at 9 months. 1) Females were significantly (α = 0.0001) longer than males. 2) In a diluent water x sex interaction, APG-EA females were significantly longer than APG-EA males (α = 0.0170) and West Branch of Canal Creek males (α = 0.0001). APG-EA males were significantly longer than West Branch of Canal Creek males (α = 0.0001). West Branch of Canal Creek females were significantly larger than West Branch of Canal Creek males (α = 0.0001). 3) A concentration x sex interaction occurred with 16 statistically significant terms which made the analysis difficult to interpret. 4) A DEN x sex interaction occurred. DEN-initiated females were longer than DEN-initiated males (α = 0.0001) and males not uninitiated (α = 0.0001). Females not initiated were longer than DEN-initiated males (α = 0.0001) and males not initiated (α = 0.0005). 5) A diluent water x DEN x sex interaction occurred which contained 10 significant terms. In general terms, the West Branch of Canal Creek DEN-initiated and males not initiated were smaller than fish in the other treatments. 6) A concentration x DEN x sex interaction occurred with a number of significant terms which was difficult to interpret.

The control fish at the APG-EA test site were significantly larger at 9 months in both weight wet (α = 0.0001) and standard length (α = 0.0001) than the controls held at CEHR.

5.5.3 Histopathology Analyses

The histopathological findings for the 6- and 9-month exposures are described in detail in the pathology report by EPL (1996). The major conclusions of the histopathology study are given below. The conclusions are taken from the EPL summary comparison at six and nine months.

A comparison of Japanese medaka initiated with DEN and exposed to 0, 1, 5, and 25% groundwater by volume in West Branch of Canal Creek water for six months and APG-EA dechlorinated tap water for the final three months of the study as reported by EPL (1996) is as follows:

> In general the number of hepatocellular neoplasms observed at nine months was greater than the number observed at six months in both male and female medaka. An exception was that there were fewer hepatocellular neoplasms among Groups 3/4 (control) males at nine months than at six months.
>
> Overall hepatocellular neoplasms were more numerous among males than among females. At

six months the number of medaka with a hepatocellular neoplasm(s) was the same in males and females in Groups 7/8 [DEN-initiated fish held in 1% groundwater by volume] and 11/12 [DEN-initiated fish held in 5% groundwater by volume].

At six months among male medaka there appeared to be a promotional effect of the Canal Creek water on hepatocellular neoplasms. At nine months among male medaka there appeared to be a promotional effect of the groundwater on hepatocellular neoplasia based on the apparently low incidence of hepatocellular neoplasms in controls (one in 17). This low incidence may be spurious in light of the incidence of hepatocellular neoplasms in DEN-initiated control males from the six month sacrifice (7 of 20 fish) and the incidence in DEN-initiated control males in dechlorinated tap water from the nine month sacrifice (8 of 40 fish). If it is speculated that the "one in 17" control incidence probably should have been higher (six to eight) then the conclusions might be that there is a slight groundwater effect on hepatocellular neoplasia at the 25% concentration and that there is a continuing promotional effect of the Canal Creek water on all groups of males initiated with DEN.

At six months among female medaka there appeared to be a promotional effect of the Canal Creek water on hepatocellular neoplasia. At six months and nine months among female medaka there was no effect of the groundwater on hepatocellular neoplasia. The number of medaka with hepatocellular neoplasia increased at nine months over six months in all groups and at nine months the incidence was greatest among control Groups 3/4 (8 of 32 affected). This distribution of neoplasms indicates that the promotional effect of the Canal Creek water which was evident at six months was still evident at nine months even though the fish were not exposed to Canal Creek water for the last three months of the study.

A comparison of Japanese medaka initiated with DEN and exposed to 0, 1, 5, and 25% groundwater by volume in APG-EA dechlorinated tap water for six and nine months as reported by EPL (1996) is as follows:

> In general the number of hepatocellular neoplasms observed at nine months was greater than the number observed at six months. An exception was that only one of 17 female medaka at six months had a hepatocellular neoplasm in Groups 19/20 [DEN-initiated fish held in 100% APG-EA tap water] and only one in 30 female medaka at nine months had a hepatocellular neoplasm in Groups 19/20.
>
> Overall, neoplasms were more numerous among males than females. An exception was that at six months one female in Groups 19/20 (controls) had a hepatocellular neoplasm and no males in Groups 19/20 had hepatocellular neoplasia.
>
> At six months among male medaka there was no effect of groundwater on hepatocellular neoplasia. At nine months there appeared to be a promotional effect of the groundwater at 25% concentration on hepatocellular neoplasia in male medaka (12 of 29 fish affected), although eight of 40 control medaka also had hepatocellular neoplasia at nine months.
>
> At six months among the female medaka there was no effect of groundwater on hepatocellular neoplasia. At nine months there appeared to be a trend of increasing percentage of hepatocellular neoplasms from controls to medaka in 25% groundwater, but the differences between groups in number of neoplasms was not great.

A comparison of Japanese medaka not initiated with DEN and exposed to 0, 1, 5, and 25% groundwater by volume in West Branch of Canal Creek water for six months and APG-EA dechlorinated tap water for the final three months of the study as reported by EPL (1996) is as follows:

> At six months among male and female medaka there was no effect of either Canal Creek water or groundwater on the incidence of hepatocellular neoplasia. At nine months among the males there was a slight effect of 25% groundwater concentration on the incidence of hepatocellular neoplasia (three of 25 medaka had hepatocellular neoplasia versus one medaka with hepatocellular neoplasia in each of the other three exposure concentrations). At nine months among the females there was no effect of groundwater exposure on

hepatocellular neoplasia.

A comparison of Japanese medaka not initiated with DEN and exposed to 0, 1, 5, and 25% groundwater by volume in APG-EA dechlorinated tap water for six and nine months as reported by EPL (1996) is as follows:

> At six months and at nine months among male and female medaka there was no effect of groundwater on the incidence of hepatocellular neoplasia.

A comparison of Japanese medaka not initiated with DEN and housed in CEHR laboratory well water for six and nine months as reported by EPL (1996) is as follows:

> At six months there were no hepatocellular neoplasms diagnosed among medaka of either sex. At nine months one hepatocellular adenoma occurred in a female that had been initiated with DEN.

Neoplasms other than hepatocellular neoplasms that occurred during the study as reported by EPL (1996) are as follows:

> Neoplasms other than hepatocellular neoplasms occurred sporadically among male and female medaka with no regard to DEN initiation or the type of diluent water in which medaka were housed. Lymphosarcoma was the most common among these sporadic neoplasms.

Non-neoplastic lesions that occurred during the study as reported by EPL (1996) are as follows:

> A number of non-neoplastic lesions occurred in a variety of tissues in both male and female medaka housed in Canal Creek water, dechlorinated tap water or laboratory well water. There was an interesting association of the occurrence of hyaline material in the glomeruli of the kidney in medaka that also had hepatocellular neoplasia, although these two lesions did not consistently occur together in the same fish. Tubular dilatation and tubular casts were common changes in the kidney that occurred more frequently among male medaka than among female medaka. Tubular degeneration and tubular mineralization, when they occurred, usually were in medaka that also had tubular casts and/or tubular dilatation.

Metazoan parasites, usually associated with granulomas, were present in a variety of tissues only in medaka that were exposed to Canal Creek water. This finding is not unexpected in fish exposed to a natural surface water which would harbor such organisms.

Increased basophilia of thyroid tissue was consistently more common among male medaka than among female medaka regardless of diluent water type or exposure to groundwater. Among medaka housed in Canal Creek water for six months and then dechlorinated tap water for three months, 19% of the females had increased basophilia of thyroid tissue although it was usually of minimal severity. This percentage in females, however, was higher than the percentage incidence in females housed in dechlorinated tap water or laboratory well water for six or nine months or in Canal Creek water for six months.

A common gross observation made at necropsy among female medaka was a large, or inflamed, or swollen anal passage or opening. At gross trimming these observations were related to a bulge of tissue in the area of the anus identified as the urinogenital papillae, an anatomic sex characteristic of female medaka. Histologically, the urinogenital papillae of a number of fish were notably larger than in others and diagnoses of hypertrophy and/or hyperplasia of the covering epithelium were made. Enlarged urinogenital papillae were noted grossly more often in medaka exposed to Canal Creek water for six months and then to dechlorinated tap water for the last three months of the study than in medaka exposed to dechlorinated tap water for nine months. There was no relationship of incidence of enlargement of urinogenital papillae to groundwater of DEN exposure. It is known that the size of the papillae may vary with the breeding season of medaka, and, experimentally, that the size may be altered by exposure to female or male hormones. An explanation for the greater incidence of enlarged papillae in medaka exposed to Canal Creek water than in medaka exposed to dechlorinated tap water is not readily apparent.

Lesions occurred in other tissues not discussed in this summary. [Additional information is given in the EPL pathology report (EPL, 1996).]

Few, if any, data are available on the potential carcinogenicity of heavy metals to the Japanese medaka (Hawkins, 1994). Beryllium and nickel have been classified by the International Agency for Research in Cancer (IARC) as probable carcinogens in mammalian models (Forum for Scientific Excellence, Inc., 1990). As in the case of metals, short-chain halogenated hydrocarbons have received little study in fish relative to other organic groups, e.g., nitroso compounds, polynuclear aromatic hydrocarbons, and aromatic amines (Hawkins et al., 1995). 1,1,2,2-Tetrachloroethane was not found to be carcinogenic to Japanese medaka exposed to concentrations up to 14 mg/L in a study by Hawkins (1991). IARC and the National Toxicology Program (NTP) have listed carbon tetrachloride and chloroform in their mammalian carcinogen lists; NTP has also listed 1,2-dichloroethane (Forum for Scientific Excellence, Inc., 1990).

One may speculate that the low incidence of carcinogenic activity in fish not initiated with DEN may be the result of the concentrations of potential carcinogens in the groundwater being too low to induce neoplasms and/or the fish model does not respond to chlorinated aliphatic hydrocarbons and heavy metals which are probable mammalian carcinogens.

5.6 Chemical Analyses

5.6.1 Comprehensive Chemical Analyses

A summary of the raw groundwater general water quality, metals, and volatile organics measured in the samples of the five bimonthly comprehensive chemical analyses is given in Table 3. The range of the lowest and highest concentrations of the five analyses is presented. The comprehensive results of each bimonthly chemical analysis are given in Appendix 1. The Appendix is organized as follows. Appendix 1, Table A1-1A lists the 100% groundwater, 100% West Branch of Canal Creek water, and 100% APG-EA tap water results obtained during Test No. 1. Table A1-1B contains the results for the chronic histopathology groundwater exposure aquaria diluted with APG-EA tap water (1, 5, and 25% groundwater by volume aquaria) obtained during Test No. 1. Table A1-1C gives the results for the chronic histopathology groundwater exposure aquaria diluted with West Branch of Canal Creek water (1, 5, and 25% groundwater by volume aquaria) obtained during Test No. 1. Appendix 1, Tables A1-2A to 2C, Tables A1-3A to 3C, Tables A1-4A to 4C, and Tables A1-5A to 5C list the data for Test Nos. 2, 3, 4 and 5, respectively. The tables in Appendix 1 include the test method and detection limit for each chemical. In contrast to Table 3, which contains only the range of materials actually measured in the samples, all

materials measured and quantified as well as materials not detected during analysis are included in Appendix 1. The original data sheets and quality control data are archived at the U.S. Army Center for Environmental Health Research (USACEHR, 1994b).

With one exception, no compounds in the following groups were detected in the groundwater, West Branch of Canal Creek water, or APG-EA tap water at EPA's quantitation limits listed in the tables of Appendix 1: 1) priority pollutant base neutrals; 2) organophosphorus pesticides; or 3) chlorinated pesticides and herbicides. Bis-(2-ethylhexyl) phthalate was reported as an analyte in Test No. 5 only for the 5% groundwater by volume aquaria diluted with West Branch of Canal Creek water. The value appears to be spurious because the compound was not listed for the 1% groundwater by volume aquaria or the 100% West Branch of Canal Creek water which was used as the diluent water.

The following munitions were not detected in any sample at a quantitation limit of 50 µg/L: 1) octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX); 2) hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX); 3) 1,3,5-trinitrobenzene (TNB); 4) N,2,4,6-tetranitro-N-methylaniline (tetryl); 5) trinitrotoluene (TNT); 6) 2,4-dinitrotoluene (2,4-DNT)); or 7) 2,6-dinitro-toluene (2,6-DNT).

The general water chemistry parameters of the groundwater summarized in Table 3 show that the groundwater has a hardness that ranges from 58 to 66 mg/L as $CaCO_3$. The pH of 3.6-4.3 is low relative to that which occurs in most surfaces waters. Some surface waters high in tannic acid or those waters impacted by acid rain may also have pH values in the same range (Baker et al., 1990). Ammonia nitrogen was <0.1 mg/L in all samples; thus, nonionized ammonia would not be expected to play a role in toxicity (Thurston et al., 1979).

Several EPA priority pollutant heavy metals were found in the groundwater (Table 3). Copper, mercury, and silver concentrations in the groundwater exceeded in one or more tests the EPA freshwater chronic numerical water quality criteria of 12 µg/L for copper (U.S. EPA, 1984a), 0.012 µg/L for mercury (U.S. EPA, 1984b), and the proposed criterion of 0.92 µg/L for silver (U.S. EPA, 1987). The copper and silver criteria are hardness dependent criteria; 100 mg/L as $CaCO_3$ was used. Aluminum was also present at high concentrations in the groundwater; however, EPA has not finalized their draft numerical water quality criteria for the metal (Potts, 1994). Thus, it is not clear whether or not the concentrations in the groundwater may exceed EPA's numerical water quality criteria for aluminum.

Thirteen chlorinated aliphatic compounds were found in the groundwater (Table 3). Several of the organics were EPA priority pollutants. None of the priority pollutant organics found in the

groundwater currently have numerical water quality criteria values because insufficient data exist to develop criteria (Potts, 1994). EPA does give the LOEC for several of the compounds where criteria are not available (carbon tetrachloride, chloroform, 1,2-dichloroethane, 1,1,2,2-tetrachloroethane, 1,1,1-trichloroethane, and 1,1,2-trichloroethane). However, all of the LOECs are one or more orders of magnitude higher than the concentrations found in the groundwater.

Eleven of the 13 volatile organics found in the groundwater had octanol water partition coefficients (log k_{ow} or log P) less than 3 (Table 4). Bioaccumulation of a material up to 100-fold above background (bioconcentration factor or BCF = 100) can occur when the log K_{ow} = 3 (U.S. EPA, 1991b). Thus, bioaccumulation was not a potential toxicological problem for 11 of the 13 volatile organics present in the groundwater. 1,2-Dichlorobenzene and 1,2,4-trichlorobenzene have K_{ows} of 3.4 and 4.2, respectively (Table 4). Both compounds were found in only one groundwater sample (Appendix 1; Table A1-1A). Because the two compounds were reported to be present in only one sample at the beginning of the study, it is difficult to determine how important bioaccumulation may be for the compounds.

5.6.2 Routine Water Quality Analyses

The raw data and various descriptive statistics for the routine water quality parameters measured in each exposure tank during the chronic histopathology study are given in Burton et al. (1995). Although some of the water quality parameters varied slightly as a function of the treatments, water quality within a given treatment was quite consistent over the 9-month study. The average temperature of all 16 West Branch of Canal Creek test aquaria over the 9-month exposure period was 23.6 vs. 24.2°C for the 16 APG-EA aquaria. The average temperature of both the West Branch of Canal Creek and APG-EA test systems fell within the range of 25 ±2 °C required in the study protocol (USACEHR, 1994a). The average dissolved oxygen concentration of all 16 West Branch of Canal Creek test aquaria over the 9-month exposure period was 7.4 vs. 8.2 mg/L for the 16 APG-EA aquaria. pH ranged from a low of 5.8 at 25% groundwater by volume to a high of 7.9 in the 100% West Branch of Canal Creek test aquaria. In the APG-EA aquaria, pH ranged from a low of 5.8 at 25% groundwater by volume to a high of 7.9 in the 1% groundwater by volume aquaria.

TABLE 4. LOG OCTANOL WATER PARTITION COEFFICIENTS OF THE ORGANIC CONTAMINANTS DETECTED IN WELL CC-27B

Contaminant	Log k_{ow}
Bromochloromethane	1.4[a]
Bromodichloromethane	2.1[b]
Carbon Tetrachloride	2.8[c]
Chloroform	1.9[b]
1,2-Dichlorobenzene	3.4[b]
1,2-Dichloroethane	1.4[a]
cis-1,2-Dichloroethene	1.8[c]
1,1,2,2-Tetrachloroethane	2.4[b]
Tetrachloroethene	2.9[b]
1,2,4-Trichlorobenzene	4.2[b]
1,1,1-Trichloroethane	2.5[b]
1,1,2-Trichloroethane	2.2[b]
Trichloroethene	2.4[b]

[a] Value taken from Howard (1993).
[b] Value taken from U.S. EPA (1991a).
[c] Value taken from Howard (1990).

SECTION 6

CONCLUSIONS

The primary objective of this study was to evaluate the potential toxicity of the groundwater *in situ* to aquatic organisms. Although microorganisms are the primary organisms present in most subsurface environments, an array of surrogate biomonitoring systems integrated into a tiered hazard framework was used in the evaluation. An array of biomonitoring assays covering several levels of biological complexity was used to maximize predictability of potential adverse pollutant effects to aquatic organisms during the 9-month evaluation. A secondary objective of the study was to evaluate, where test systems were appropriate for use in low salinity waters, the potential toxicity of West Branch of Canal Creek water. The West Branch of Canal Creek studies were conducted concurrently with the groundwater studies to obtain background data on the potential toxicity of the creek water. Only aqueous phase assays were used in the water column studies of West Branch of Canal Creek water; no sediment systems were studied.

Several U.S Environmental Protection Agency (EPA) priority pollutant heavy metals were found in the groundwater. Copper, mercury, and silver concentrations in the groundwater exceeded, in one or more tests, EPA's numerical water quality criteria for the specific metal. Aluminum was also present at high concentrations in the groundwater; however, EPA has not finalized their draft numerical water quality criteria for the metal. Thus, it is not clear whether or not the concentrations in the groundwater may exceed EPA's numerical water quality criteria for aluminum.

Thirteen chlorinated aliphatic compounds were found in the groundwater, several of which are EPA priority pollutants. None of the priority pollutant organics found in the groundwater currently have numerical water quality criteria values; however, lowest observed effect levels (LOEL) for several of the compounds are available. All of the LOELs are one or more orders of magnitude higher than the concentrations found in the groundwater.

Eleven of the 13 volatile organics found in the groundwater had octanol water partition coefficients (log k_{ow} or log P) less than 3. Thus, bioaccumulation was not a potential toxicological problem for most of the volatile organics present in the groundwater. 1,2-Dichlorobenzene and 1,2,4-trichlorobenzene, which have K_{ows} greater than 3, were found in only one groundwater sample during the study. Because the two compounds were present in only one sample at the beginning of the study, it is difficult to determine how important bioaccumulation may be for the compounds.

An array of eight biomonitoring systems integrated into a tiered hazard framework was used in the 9-month study. The biomonitoring systems included a number of endpoints. The pH of the groundwater from well CC-27B was ≈4; thus, many of the assays were conducted at both pH 4 and pH 7. The toxicity at pH 7 was studied so that the data could be used, if necessary, in the Phase 2 hazard assessment of the groundwater as it enters the West Branch of Canal Creek which has pH values close to the neutral range.

Toxicity was detected at various groundwater concentrations by 6 of the 8 biomonitoring systems. The Ames assay for mutagenicity was negative in all cases for groundwater, West Branch of Canal Creek water, and filtered APG-EA tap water. Three chemical mutagens (carbon tetrachloride, 1,2-dichloroethane, and trichloroethene) were found in the groundwater. The lack of mutagenic activity in the groundwater concentrated 100X suggests that the concentrations of the mutagens are too low to induce significant mutations in the Ames assay.

Differences in Japanese medaka (Oryzias latipes) growth were found in a chronic 9-month histopathology assay when the fish were exposed to 1, 5 and 25% groundwater by volume diluted with either APG-EA dechlorinated tap water or West Branch of Canal Creek surface water. In general, the fish were smaller when grown in groundwater diluted with West Branch of Canal Creek water compared to those reared in groundwater diluted with APG-EA dechlorinated tap water. Most females were larger than males when reared in groundwater diluted with either West Branch of Canal Creek water or APG-EA dechlorinated tap water.

Experimental Pathology Laboratories, Inc. (EPL), Herndon, VA, analyzed the Japanese medaka in the chronic nine-month study for incidences of hepatocellular neoplasia, neoplasms other than hepatocellular neoplasms, and non-neoplastic lesions and concluded the following. "...at nine months among male and female medaka there was no effect of groundwater on the incidence of hepatocellular neoplasia [at concentrations up to 25% groundwater by volume (highest concentrations studied) when APG-EA dechlorinated tap water was used as diluent water]." "At nine months among the males there was a slight effect of 25% groundwater concentration on the incidence of hepatocellular neoplasia...[and]...among the females there was no effect of groundwater exposure on hepatocellular neoplasia [when West Branch of Canal Creek water was used as diluent water for six months and dechlorinated tap water for three additional months]."

EPL found the following at the end of the nine-month study when Japanese medaka were initiated for 48 h at 13 days of age with 10 mg/L diethylnitrosamine (DEN). "At nine months there appeared to be a promotional effect of the groundwater at 25% concentration on hepatocellular neoplasia in male medaka (12 of

29 fish affected), although eight of 40 control medaka also had hepatocellular neoplasia at nine months [in fish exposed to 25% groundwater by volume diluted with APG-EA dechlorinated tap water]." "At nine months there appeared to be a trend of increasing percentage of hepatocellular neoplasms from controls in 25% groundwater, but the differences between groups in number of neoplasms was not great."

In DEN-initiated fish exposed to West Branch of Canal Creek water for six months followed by three months of exposure to groundwater in APG-EA dechlorinated tap water, EPL concluded "At nine months among male medaka there appeared to be a promotional effect of the groundwater on hepatocellular neoplasia based on the apparently low incidence of hepatocellular neoplasms in controls...This low incidence may be spurious..." "At six months among female medaka there appeared to be a promotional effect of the Canal Creek water on hepatocellular neoplasia. At six and nine months among female medaka there was no effect of the groundwater on hepatocellular neoplasia. The number of medaka with hepatocellular neoplasia increased at nine months over six months in all groups and at nine months the incidence was greatest among control Groups..."

The groundwater was acutely toxic at pH 4 to a green alga (Selenastrum capricornutum), cladoceran (Ceriodaphnia dubia), fathead minnow (Pimephales promelas), and Japanese medaka. From an acute toxicity standpoint, the groundwater appeared to be less toxic to the green alga at pH 7. The groundwater was not acutely toxic at pH 7 to the cladoceran, fathead minnow, or Japanese medaka.

The lowest concentration of groundwater that caused no observable adverse effect (NOEC) at pH 4, in the test systems in which the NOEC value could be determined, was 10% groundwater by volume. A NOEC of 10% groundwater by volume occurred in 3 out of 5 tests for the green alga (S. capricornutum); 4 out of 5 tests in both a 7-d cladoceran (C. dubia) and a 96-h frog (Xenopus laevis) embryo teratogenesis assay - Xenopus (FETAX). A NOEC of 18% groundwater by volume occurred in 2 of 5 tests in a 7-d fathead minnow (P. promelas) test. The groundwater was not toxic at pH 7 in the 7-d fathead minnow test and in 2 of 5 FETAX assays. The NOEC (18% groundwater by volume) was higher at pH 7 in 3 of the 5 FETAX assays. The 10% groundwater by volume NOEC for the green alga and cladoceran at pH 4, however, was essentially the same when the organisms were exposed to buffered groundwater at pH 7.

In conclusion, 6 of the 8 biomonitoring systems showed that the groundwater in the Canal Creek aquifer was toxic. Thus, the Phase 2 analyses followed by the preliminary hazard assessment of the groundwater discharge into West Branch of Canal Creek should be conducted as proposed.

SECTION 7

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APPENDIX 1

COMPREHENSIVE CHEMICAL ANALYSES CONDUCTED ON RAW (pH ≈4) CANAL CREEK GROUNDWATER (WELL CC-27B), WEST BRANCH OF CANAL CREEK WATER, APG-EA TAP WATER, AND CHRONIC HISTOPATHOLOGY EXPOSURE TANKS

TABLE A1-1A. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY GROUNDWATER (WELL NO. CC-27B), WEST BRANCH OF CANAL CREEK SURFACE WATER, AND APG-EA TAP WATER (TEST NO. 1) - GENERAL WATER QUALITY[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Alkalinity ($CaCO_3$)	310.1	1.0	<1.0	61.2	30
Ammonia Nitrogen (N)	350.3	0.01	0.035	0.052	0.032
Bromide	320.1	0.2	<0.2	0.4	<0.2
Chloride (Cl)	508	1.0	78.6	109	23.8
Cyanide (Cn)	335.2	0.002	<0.002	<0.002	<0.002
Fluoride (F)	340.2	0.01	0.349	0.200	0.449
Hardness ($CaCO_3$)	AA	_	63.5	95.6	67.0
pH (electrometric)	150.1	_	4.08	6.70	6.69
Nitrate (N)	ISE	0.01	1.97	0.591	3.01
Nitrite (N)	354.1	0.001	<0.001	<0.001	<0.001
Phosphate (P)	365.3	0.01	0.151	0.153	0.302
Specific Conductance @ 25 °C	120.1	1.0	427	477	188
Sulfate (SO_4)	375.3	1.0	103	17.5	2.3
Sulfide (H_2S)	376.1	0.02	<0.02	<0.02	<0.02
Total Organic Carbon	415.1	2.0	2.6	8.3	<2.0
Total Suspended Solids	160.2	1.0	<1.0	11.6	<1.0

[a] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-1A. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Aluminum (Al)	200.7	25.6	2380	250	37.3
Antimony (Sb)	200.7	14.1	<14.1	<14.1	<14
Arsenic (As)	200.7	45	<45	<45	<45
Beryllium (Be)	200.7	0.5	1.8	<0.5	<0.5
Boron	200.7	10	352	233	90.3
Cadmium (Cd)	200.7	1.5	<1.5	<1.5	<1.5
Calcium (Ca)	200.7	30.6	17000	19600	18900
Chromium (Cr)	200.7	6	<6	<5	<6
Cobalt	200.7	1.3	45.9	2.6	1.9
Copper (Cu)	200.7	3	16.6	6.8	9.9
Iron	200.7	2.5	5.5	1250	12.0
Lead (Pb)	200.7	14.5	<14.5	<14.5	<14.5
Magnesium (Mg)	200.7	29.5	5990	13300	5630
Manganese (Mn)	200.7	0.97	734	175	<0.97
Mercury (Hg)	245.1	0.1	0.1	<0.1	<0.1
Molybdenum (Mo)	200.7	28.9	<28.9	<28.9	<28.9
Nickel (Ni)	200.7	2.9	24.0	4.2	6.5
Potassium (K)	200.7	40	2000	3840	2210
Selenium (Se)	200.7	11.1	<11.1	<11.1	<11.1
Silver (Ag)	200.7	6.7	<6.7	<6.7	<6.7
Sodium (Na)	200.7	30	60500	61600	9630
Thallium	200.7	75	<75	<75	<75
Tin (Sn)	200.7	9.7	<9.7	<9.7	<9.7
Zinc (Zn)	200.7	1.5	88.4	44.8	251

[a] All results expressed as μg/L.

TABLE A1-1A. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	ND	ND	ND
Bromodichloromethane	8021	0.5	0.78	ND	3.3
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	57.7	16.8	ND
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	ND
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	103	15.3	19.2
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	0.53	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	3.5	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1A. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
cis-1,2-Dichloroethene	8021	0.5	1.3	0.59	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	57.8	7.98	ND
Tetrachloroethene	8021	0.5	3.49	3.02	ND
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	0.6	ND	ND
1,1,1-Trichloroethane	8021	0.5	ND	ND	ND
1,1,2-Trichloroethane	8021	0.5	1.08	0.51	ND
Trichloroethene	8021	0.5	64.4	1.74	ND
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND[b]	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as $\mu g/L$.
[b] A spurious result of 0.52 $\mu g/L$ was originally reported; the error was corrected by the analytical laboratory.

TABLE A1-1A. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Bis-(2-chloroethoxy) Methane	8270	2.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	2.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	2.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	2.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	2.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	2.0	ND	ND	ND
2-Chloronapthalene	8270	2.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	2.0	ND	ND	ND
Chrysene	8270	2.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	3.0	ND	ND	ND
Acenaphthylene	8270	2.0	ND	ND	ND
1,2-Dichlorobenzene	8270	2.0	ND	ND	ND
1,3-Dichlorobenzene	8270	2.0	ND	ND	ND
1,4-Dichlorobenzene	8270	2.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	5.0	ND	ND	ND
Diethyl Phthalate	8270	2.0	ND	ND	ND
Dimethyl Phthalate	8270	5.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	2.0	ND	ND	ND
2,4-Dinitrotoluene	8270	4.0	ND	ND	ND
2,6-Dinitrotoluene	8270	4.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	2.0	ND	ND	ND
Fluoranthene	8270	2.0	ND	ND	ND
Fluorene	8270	2.0	ND	ND	ND
Hexachlorobenzene	8270	2.0	ND	ND	ND
Hexachlorobutadiene	8270	3.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	5.0	ND	ND	ND
Hexachloroethane	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1A. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Indeno[1,2,3-cd]pyrene	8270	3.0	ND	ND	ND
Isophorone	8270	2.0	ND	ND	ND
Naphthalene	8270	2.0	ND	ND	ND
Anthracene	8270	2.0	ND	ND	ND
Nitrobenzene	8270	4.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	4.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	4.0	ND	ND	ND
Phenanthrene	8270	2.0	ND	ND	ND
Pyrene	8270	2.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	2.0	ND	ND	ND
Benzo(a)anthracene	8270	3.0	ND	ND	ND
Benzo(a)pyrene	8270	3.0	ND	ND	ND
Benzo(b)fluoranthene	8270	3.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	3.0	ND	ND	ND
Benzo(k)fluoranthene	8270	3.0	ND	ND	ND
Benzidine	8270	4.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	4.0	ND	ND	ND
N-Nitrosodimethylamine	8270	4.0	ND	ND	ND
Acenaphthene	8270	2.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	3.0	ND	ND	ND
4-Chloroaniline	8270	2.0	ND	ND	ND
2-Methylnaphthalene	8270	2.0	ND	ND	ND
2-Nitroaniline	8270	5.0	ND	ND	ND
4-Nitroaniline	8270	5.0	ND	ND	ND
Dibenzofuran	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1A. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Phenol	8270	2.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	2.0	ND	ND	ND
2-Chlorophenol	8270	2.0	ND	ND	ND
2,4-Dichlorophenol	8270	2.0	ND	ND	ND
2,4-Dimethylphenol	8270	2.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	5.0	ND	ND	ND
2,4-Dinitrophenol	8270	5.0	ND	ND	ND
2-Nitrophenol	8270	5.0	ND	ND	ND
4-Nitrophenol	8270	5.0	ND	ND	ND
p-Chloro-m-cresol	8270	2.0	ND	ND	ND
Pentachlorophenol	8270	5.0	ND	ND	ND
p-Cresol	8270	2.0	ND	ND	ND
o-Cresol	8270	2.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1A. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Azinphos-methyl	8140	0.10	ND	ND	ND
Bolstar (Sulprofos)	8140	0.07	ND	ND	ND
Coumaphos	8140	0.20	ND	ND	ND
Demeton, -O, -S	8140	0.12	ND	ND	ND
Diazinon	8140	0.20	ND	ND	ND
Dichlorvos	8140	0.80	ND	ND	ND
Dimethoate	8140	0.26	ND	ND	ND
Disulfoton	8140	0.07	ND	ND	ND
EPN	8140	0.04	ND	ND	ND
Ethoprop	8140	0.20	ND	ND	ND
Fensulfothion	8140	0.08	ND	ND	ND
Fenthion	8140	0.08	ND	ND	ND
Malathion	8140	0.11	ND	ND	ND
Merphos	8140	0.20	ND	ND	ND
Mevinphos	8140	0.50	ND	ND	ND
Naled	8140	0.50	ND	ND	ND
Parathion	8140	0.12	ND	ND	ND
Phorate	8140	0.04	ND	ND	ND
Ronnel	8140	0.07	ND	ND	ND
Sulfotep	8140	0.07	ND	ND	ND
TEPP	8140	0.80	ND	ND	ND
Tetrachlorovinphos	8140	0.80	ND	ND	ND
Tokuthion	8140	0.07	ND	ND	ND
Trichloronate	8140	0.80	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1A. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C	100% APG-EA
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Herbicides:					
2,4-D	8150	1.500	ND	ND	ND
2,4,5-TP	8150	0.075	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1B. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY CHRONIC HISTOPATHOLOGY GROUNDWATER EXPOSURE AQUARIA DILUTED WITH APG-EA TAP WATER (TEST NO. 1) - GENERAL WATER QUALITY[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Alkalinity ($CaCO_3$)	310.1	1.0	20.0	27.6	29.6
Ammonia Nitrogen (N)	350.3	0.01	0.054	0.053	0.051
Bromide	320.1	0.2	<0.2	<0.2	<0.2
Chloride (Cl)	508	1.0	37.3	26.3	24.3
Cyanide (Cn)	335.2	0.002	<0.002	<0.002	<0.002
Fluoride (F)	340.2	0.01	0.426	0.469	0.480
Hardness ($CaCO_3$)	AA	_	67.8	67.5	68.4
pH (electrometric)	150.1	_	6.60	6.90	6.89
Nitrate (N)	ISE	0.01	2.67	2.91	2.97
Nitrite (N)	354.1	0.001	<0.001	<0.001	<0.001
Phosphate (P)	365.3	0.01	0.311	0.302	0.364
Specific Conductance @ 25 °C	120.1	1.0	254	199	192
Sulfate (SO_4)	375.3	1.0	29.1	15.8	14.1
Sulfide (H_2S)	376.1	0.02	<0.02	<0.02	<0.02
Total Organic Carbon	415.1	2.0	4.6	2.7	4.4
Total Suspended Solids	160.2	1.0	<1.0	<1.0	<1.0

[a] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-1B. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Aluminum (Al)	200.7	25.6	677	139	64.8
Antimony (Sb)	200.7	14.1	<14.5	<14.1	<14.1
Arsenic (As)	200.7	45	<45	<45	<45
Beryllium (Be)	200.7	0.5	<0.5	<0.5	<5
Boron	200.7	10	188	221	155
Cadmium (Cd)	200.7	1.5	<1.5	<1.5	<1.5
Calcium (Ca)	200.7	30.6	19000	19000	19400
Chromium (Cr)	200.7	6	<6	<6	<6
Cobalt	200.7	1.3	10.9	2.9	<1.3
Copper (Cu)	200.7	3	6	<3	10.3
Iron	200.7	2.5	14.5	14.5	7.9
Lead (Pb)	200.7	14.5	<14.5	<14.5	<14.5
Magnesium (Mg)	200.7	29.5	5790	5710	5680
Manganese (Mn)	200.7	0.97	187	36.5	8.7
Mercury (Hg)	245.1	0.1	0.13	<0.1	<0.1
Molybdenum (Mo)	200.7	28.9	<28.9	<28.9	b
Nickel (Ni)	200.7	2.9	10.5	<2.9	b
Potassium (K)	200.7	40	2190	2190	b
Selenium (Se)	200.7	11.1	<11.1	<11.1	b
Silver (Ag)	200.7	6.7	<6.7	<6.7	b
Sodium (Na)	200.7	30	22300	12200	b
Thallium	200.7	75	<75	<75	<75
Tin (Sn)	200.7	9.7	<9.7	<9.7	<9.7
Zinc (Zn)	200.7	1.5	196	207	227

[a] All results expressed as μg/L.
[b] Result not reported because of an error in the anaytical laboratory report.

TABLE A1-1B. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	ND	ND	ND
Bromodichloromethane	8021	0.5	1.88	2.38	2.41
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	6.43	1.41	ND
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	ND
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	22.0	14.7	12.4
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	ND	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1B. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
cis-1,2-Dichloroethene	8021	0.5	ND	ND	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	10.5	2.32	ND
Tetrachloroethene	8021	0.5	ND	ND	ND
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	ND	ND	ND
1,1,2-Trichloroethane	8021	0.5	0.51	ND	ND
Trichloroethene	8021	0.5	7.33	1.75	ND
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1B. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Bis-(2-chloroethoxy) Methane	8270	2.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	2.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	2.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	2.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	2.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	2.0	ND	ND	ND
2-Chloronapthalene	8270	2.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	2.0	ND	ND	ND
Chrysene	8270	2.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	3.0	ND	ND	ND
Acenaphthylene	8270	2.0	ND	ND	ND
1,2-Dichlorobenzene	8270	2.0	ND	ND	ND
1,3-Dichlorobenzene	8270	2.0	ND	ND	ND
1,4-Dichlorobenzene	8270	2.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	5.0	ND	ND	ND
Diethyl Phthalate	8270	2.0	ND	ND	ND
Dimethyl Phthalate	8270	5.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	2.0	ND	ND	ND
2,4-Dinitrotoluene	8270	4.0	ND	ND	ND
2,6-Dinitrotoluene	8270	4.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	2.0	ND	ND	ND
Fluoranthene	8270	2.0	ND	ND	ND
Fluorene	8270	2.0	ND	ND	ND
Hexachlorobenzene	8270	2.0	ND	ND	ND
Hexachlorobutadiene	8270	3.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	5.0	ND	ND	ND
Hexachloroethane	8270	2.0	ND	ND	ND

[a] All results expressed as $\mu g/L$.

TABLE A1-1B. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Indeno[1,2,3-cd]pyrene	8270	3.0	ND	ND	ND
Isophorone	8270	2.0	ND	ND	ND
Naphthalene	8270	2.0	ND	ND	ND
Anthracene	8270	2.0	ND	ND	ND
Nitrobenzene	8270	4.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	4.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	4.0	ND	ND	ND
Phenanthrene	8270	2.0	ND	ND	ND
Pyrene	8270	2.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	2.0	ND	ND	ND
Benzo(a)anthracene	8270	3.0	ND	ND	ND
Benzo(a)pyrene	8270	3.0	ND	ND	ND
Benzo(b)fluoranthene	8270	3.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	3.0	ND	ND	ND
Benzo(k)fluoranthene	8270	3.0	ND	ND	ND
Benzidine	8270	4.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	4.0	ND	ND	ND
N-Nitrosodimethylamine	8270	4.0	ND	ND	ND
Acenaphthene	8270	2.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	3.0	ND	ND	ND
4-Chloroaniline	8270	2.0	ND	ND	ND
2-Methylnaphthalene	8270	2.0	ND	ND	ND
2-Nitroaniline	8270	5.0	ND	ND	ND
4-Nitroaniline	8270	5.0	ND	ND	ND
Dibenzofuran	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1B. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Phenol	8270	2.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	2.0	ND	ND	ND
2-Chlorophenol	8270	2.0	ND	ND	ND
2,4-Dichlorophenol	8270	2.0	ND	ND	ND
2,4-Dimethylphenol	8270	2.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	5.0	ND	ND	ND
2,4-Dinitrophenol	8270	5.0	ND	ND	ND
2-Nitrophenol	8270	5.0	ND	ND	ND
4-Nitrophenol	8270	5.0	ND	ND	ND
p-Chloro-m-cresol	8270	2.0	ND	ND	ND
Pentachlorophenol	8270	5.0	ND	ND	ND
p-Cresol	8270	2.0	ND	ND	ND
o-Cresol	8270	2.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1B. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Azinphos-methyl	8140	0.10	ND	ND	ND
Bolstar (Sulprofos)	8140	0.07	ND	ND	ND
Coumaphos	8140	0.20	ND	ND	ND
Demeton, -O, -S	8140	0.12	ND	ND	ND
Diazinon	8140	0.20	ND	ND	ND
Dichlorvos	8140	0.80	ND	ND	ND
Dimethoate	8140	0.26	ND	ND	ND
Disulfoton	8140	0.07	ND	ND	ND
EPN	8140	0.04	ND	ND	ND
Ethoprop	8140	0.20	ND	ND	ND
Fensulfothion	8140	0.08	ND	ND	ND
Fenthion	8140	0.08	ND	ND	ND
Malathion	8140	0.11	ND	ND	ND
Merphos	8140	0.20	ND	ND	ND
Mevinphos	8140	0.50	ND	ND	ND
Naled	8140	0.50	ND	ND	ND
Parathion	8140	0.12	ND	ND	ND
Phorate	8140	0.04	ND	ND	ND
Ronnel	8140	0.07	ND	ND	ND
Sulfotep	8140	0.07	ND	ND	ND
TEPP	8140	0.80	ND	ND	ND
Tetrachlorovinphos	8140	0.80	ND	ND	ND
Tokuthion	8140	0.07	ND	ND	ND
Trichloronate	8140	0.80	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1B. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Herbicides:					
2,4-D	8150	1.500	ND	ND	ND
2,4,5-TP	8150	0.075	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1C. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY CHRONIC HISTOPATHOLOGY GROUNDWATER EXPOSURE AQUARIA DILUTED WITH WEST BRANCH OF CANAL CREEK WATER (TEST NO. 1) - GENERAL WATER QUALITY[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Alkalinity ($CaCO_3$)	310.1	1.0	47.6	58.2	60.4
Ammonia Nitrogen (N)	350.3	0.01	0.087	0.102	0.091
Bromide	320.1	0.2	<0.2	0.3	0.3
Chloride (Cl)	508	1.0	117	126	132
Cyanide (Cn)	335.2	0.002	<0.002	<0.002	<0.002
Fluoride (F)	340.2	0.01	0.215	0.227	0.211
Hardness ($CaCO_3$)	AA	_	88.4	96.2	97.5
pH (electrometric)	150.1	_	6.62	6.94	b
Nitrate (N)	ISE	0.01	1.04	0.670	0.636
Nitrite (N)	354.1	0.001	0.001	0.002	0.002
Phosphate (P)	365.3	0.01	0.153	0.224	0.134
Specific Conductance @ 25 °C	120.1	1.0	516	530	561
Sulfate (SO_4)	375.3	1.0	38.8	22.5	18.8
Sulfide (H_2S)	376.1	0.02	<0.02	<0.02	<0.02
Total Organic Carbon	415.1	2.0	6.8	7.0	7.5
Total Suspended Solids	160.2	1.0	4.9	5.1	6.1

[a] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.
[b] Result not reported because of an error in the analytical laboratory report.

TABLE A1-1C. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W
Aluminum (Al)	200.7	25.6	533	319	174
Antimony (Sb)	200.7	14.1	<14.1	<14.1	<14.1
Arsenic (As)	200.7	45	<45	<45	<45
Beryllium (Be)	200.7	0.5	<0.5	<0.5	<0.5
Boron	200.7	10	255	482	172
Cadmium (Cd)	200.7	1.5	<1.5	<1.5	<1.5
Calcium (Ca)	200.7	30.6	18100	18600	18700
Chromium (Cr)	200.7	6	<6	<6	<6
Cobalt	200.7	1.3	10.6	<1.3	2.8
Copper (Cu)	200.7	3	7.5	8.2	7.7
Iron	200.7	2.5	872	1100	950
Lead (Pb)	200.7	14.5	<14.5	<14.5	<14.5
Magnesium (Mg)	200.7	29.5	12300	14200	14500
Manganese (Mn)	200.7	0.97	303	130	96.9
Mercury (Hg)	245.1	0.1	0.19	<0.1	0.24
Molybdenum (Mo)	200.7	28.9	<28.9	<28.9	<28.9
Nickel (Ni)	200.7	2.9	13.4	15.5	5.0
Potassium (K)	200.7	40	3610	4240	4440
Selenium (Se)	200.7	11.1	<11.1	<11.1	<11.1
Silver (Ag)	200.7	6.7	<6.7	<6.7	<6.7
Sodium (Na)	200.7	30	66500	73000	73100
Thallium	200.7	75.9	<75	<75	<75
Tin (Sn)	200.7	9.7	<9.7	<9.7	<9.7
Zinc (Zn)	200.7	1.5	42.6	45.8	32.4

[a] All results expressed as μg/L.

TABLE A1-1C. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	ND	ND	ND
Bromodichloromethane	8021	0.5	ND	ND	ND
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	12.3	8.1	7.51
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	ND
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	22.1	10.1	9.33
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	0.71	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1C. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
cis-1,2-Dichloroethene	8021	0.5	ND	ND	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	15.5	6.26	5.02
Tetrachloroethene	8021	0.5	1.59	1.52	1.62
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	ND	ND	ND
1,1,2-Trichloroethane	8021	0.5	[b]	0.71	0.67
Trichloroethene	8021	0.5	8.6	2.42	1.15
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.
[b] Result not given in analytical laboratory report.

TABLE A1-1C. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Bis-(2-chloroethoxy) Methane	8270	2.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	2.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	2.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	2.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	2.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	2.0	ND	ND	ND
2-Chloronapthalene	8270	2.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	2.0	ND	ND	ND
Chrysene	8270	2.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	3.0	ND	ND	ND
Acenaphthylene	8270	2.0	ND	ND	ND
1,2-Dichlorobenzene	8270	2.0	ND	ND	ND
1,3-Dichlorobenzene	8270	2.0	ND	ND	ND
1,4-Dichlorobenzene	8270	2.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	5.0	ND	ND	ND
Diethyl Phthalate	8270	2.0	ND	ND	ND
Dimethyl Phthalate	8270	5.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	2.0	ND	ND	ND
2,4-Dinitrotoluene	8270	4.0	ND	ND	ND
2,6-Dinitrotoluene	8270	4.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	2.0	ND	ND	ND
Fluoranthene	8270	2.0	ND	ND	ND
Fluorene	8270	2.0	ND	ND	ND
Hexachlorobenzene	8270	2.0	ND	ND	ND
Hexachlorobutadiene	8270	3.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	5.0	ND	ND	ND
Hexachloroethane	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1C. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Indeno[1,2,3-cd]pyrene	8270	3.0	ND	ND	ND
Isophorone	8270	2.0	ND	ND	ND
Naphthalene	8270	2.0	ND	ND	ND
Anthracene	8270	2.0	ND	ND	ND
Nitrobenzene	8270	4.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	4.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	4.0	ND	ND	ND
Phenanthrene	8270	2.0	ND	ND	ND
Pyrene	8270	2.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	2.0	ND	ND	ND
Benzo(a)anthracene	8270	3.0	ND	ND	ND
Benzo(a)pyrene	8270	3.0	ND	ND	ND
Benzo(b)fluoranthene	8270	3.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	3.0	ND	ND	ND
Benzo(k)fluoranthene	8270	3.0	ND	ND	ND
Benzidine	8270	4.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	4.0	ND	ND	ND
N-Nitrosodimethylamine	8270	4.0	ND	ND	ND
Acenaphthene	8270	2.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	3.0	ND	ND	ND
4-Chloroaniline	8270	2.0	ND	ND	ND
2-Methylnaphthalene	8270	2.0	ND	ND	ND
2-Nitroaniline	8270	5.0	ND	ND	ND
4-Nitroaniline	8270	5.0	ND	ND	ND
Dibenzofuran	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1C. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Phenol	8270	2.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	2.0	ND	ND	ND
2-Chlorophenol	8270	2.0	ND	ND	ND
2,4-Dichlorophenol	8270	2.0	ND	ND	ND
2,4-Dimethylphenol	8270	2.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	5.0	ND	ND	ND
2,4-Dinitrophenol	8270	5.0	ND	ND	ND
2-Nitrophenol	8270	5.0	ND	ND	ND
4-Nitrophenol	8270	5.0	ND	ND	ND
p-Chloro-m-cresol	8270	2.0	ND	ND	ND
Pentachlorophenol	8270	5.0	ND	ND	ND
p-Cresol	8270	2.0	ND	ND	ND
o-Cresol	8270	2.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1C. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Azinphos-methyl	8140	0.10	ND	ND	ND
Bolstar (Sulprofos)	8140	0.07	ND	ND	ND
Coumaphos	8140	0.20	ND	ND	ND
Demeton, -O, -S	8140	0.12	ND	ND	ND
Diazinon	8140	0.20	ND	ND	ND
Dichlorvos	8140	0.80	ND	ND	ND
Dimethoate	8140	0.26	ND	ND	ND
Disulfoton	8140	0.07	ND	ND	ND
EPN	8140	0.04	ND	ND	ND
Ethoprop	8140	0.20	ND	ND	ND
Fensulfothion	8140	0.08	ND	ND	ND
Fenthion	8140	0.08	ND	ND	ND
Malathion	8140	0.11	ND	ND	ND
Merphos	8140	0.20	ND	ND	ND
Mevinphos	8140	0.50	ND	ND	ND
Naled	8140	0.50	ND	ND	ND
Parathion	8140	0.12	ND	ND	ND
Phorate	8140	0.04	ND	ND	ND
Ronnel	8140	0.07	ND	ND	ND
Sulfotep	8140	0.07	ND	ND	ND
TEPP	8140	0.80	ND	ND	ND
Tetrachlorovinphos	8140	0.80	ND	ND	ND
Tokuthion	8140	0.07	ND	ND	ND
Trichloronate	8140	0.80	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-1C. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Herbicides:					
2,4-D	8150	1.500	ND	ND	ND
2,4,5-TP	8150	0.075	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2A. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY GROUNDWATER (WELL NO. CC-27B), WEST BRANCH OF CANAL CREEK SURFACE WATER, AND APG-EA TAP WATER (TEST NO. 2) - GENERAL WATER QUALITY[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Alkalinity ($CaCO_3$)	310.1	1.0	<1	57.2	31.0
Ammonia Nitrogen (N)	350.3	0.01	0.055	0.272	0.050
Bromide	320.1	0.2	<0.2	<0.02?	<0.2
Chloride (Cl)	508	1.0	77.2	487	22.5
Cyanide (Cn)	335.2	0.002	<0.005	<0.005	<0.005
Fluoride (F)	340.2	0.01	0.307	0.178	0.854
Hardness ($CaCO_3$)	AA	_	59.5	123	65.2
pH (electrometric)	150.1	_	4.28	6.53	6.98
Nitrate (N)	ISE	0.01	1.91	1.32	2.43
Nitrite (N)	354.1	0.001	<0.001	0.012	<0.001
Phosphate (P)	365.3	0.01	0.428	0.784	0.674
Specific Conductance @ 25 °C	120.1	1.0	336	674	172
Sulfate (SO_4)	375.3	1.0	94.0	41.6	20.6
Sulfide (H_2S)	376.1	0.02	<0.02	<0.02	<0.02
Total Organic Carbon	415.1	2.0	<2.0	6.5	<2.0
Total Suspended Solids	160.2	1.0	<1.0	42.3	<1.0

[a] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-2A. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Aluminum (Al)	200.7	25.6	2090	846	214
Antimony (Sb)	200.7	14.1	<14.1	<14.1	<14.1
Arsenic (As)	200.7	45	<45	<45	<45
Beryllium (Be)	200.7	0.5	<0.5	<0.5	<0.5
Boron	200.7	10	409	351	490
Cadmium (Cd)	200.7	1.5	<1.5	<1.5	<1.5
Calcium (Ca)	200.7	30.6	16000	21700	18500
Chromium (Cr)	200.7	6	<6	8.7	<6
Cobalt	200.7	1.3	44.6	5.2	<1.3
Copper (Cu)	200.7	3	24.4	12.5	45.7
Iron	200.7	2.5	34.5	2820	41.8
Lead (Pb)	200.7	14.5	<14.5	16.3	<14.5
Magnesium (Mg)	200.7	29.5	5580	19700	5410
Manganese (Mn)	200.7	0.97	848	942	2.9
Mercury (Hg)	245.1	0.1	<0.1	<0.1	<0.1
Molybdenum (Mo)	200.7	28.9	<28.9	<20?	<28.9
Nickel (Ni)	200.7	2.9	24.7	11.3	12.6
Potassium (K)	200.7	40	2010	5720	3440
Selenium (Se)	200.7	11.1	<11.1	<11.1	<11.1
Silver (Ag)	200.7	6.7	<13.6	<13.6	<13.6
Sodium (Na)	200.7	30	61300	126000	10400
Thallium	200.7	75	<75	<75	<75
Tin (Sn)	200.7	9.7	<9.7	<9.7	<9.7
Zinc (Zn)	200.7	1.5	78.4	98.1	272

[a] All results expressed as μg/L.

TABLE A1-2A. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	ND	ND	ND
Bromodichloromethane	8021	0.5	97.9	2.1	5.3
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	55.9	15.1	ND
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	1.7
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	54.0	8.5	29.5
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	2.5	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2A. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
cis-1,2-Dichloroethene	8021	0.5	1.3	0.9	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	57.1	7.4	ND
Tetrachloroethene	8021	0.5	6.0	3.0	ND
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	ND	ND	ND
1,1,2-Trichloroethane	8021	0.5	ND	ND	ND
Trichloroethene	8021	0.5	91.7	3.4	ND
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2A. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Bis-(2-chloroethoxy) Methane	8270	2.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	2.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	2.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	2.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	2.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	2.0	ND	ND	ND
2-Chloronapthalene	8270	2.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	2.0	ND	ND	ND
Chrysene	8270	2.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	3.0	ND	ND	ND
Acenaphthylene	8270	2.0	ND	ND	ND
1,2-Dichlorobenzene	8270	2.0	ND	ND	ND
1,3-Dichlorobenzene	8270	2.0	ND	ND	ND
1,4-Dichlorobenzene	8270	2.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	5.0	ND	ND	ND
Diethyl Phthalate	8270	2.0	ND	ND	ND
Dimethyl Phthalate	8270	5.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	2.0	ND	ND	ND
2,4-Dinitrotoluene	8270	4.0	ND	ND	ND
2,6-Dinitrotoluene	8270	4.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	2.0	ND	ND	ND
Fluoranthene	8270	2.0	ND	ND	ND
Fluorene	8270	2.0	ND	ND	ND
Hexachlorobenzene	8270	2.0	ND	ND	ND
Hexachlorobutadiene	8270	3.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	5.0	ND	ND	ND
Hexachloroethane	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2A. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Indeno[1,2,3-cd]pyrene	8270	3.0	ND	ND	ND
Isophorone	8270	2.0	ND	ND	ND
Naphthalene	8270	2.0	ND	ND	ND
Anthracene	8270	2.0	ND	ND	ND
Nitrobenzene	8270	4.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	4.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	4.0	ND	ND	ND
Phenanthrene	8270	2.0	ND	ND	ND
Pyrene	8270	2.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	2.0	ND	ND	ND
Benzo(a)anthracene	8270	3.0	ND	ND	ND
Benzo(a)pyrene	8270	3.0	ND	ND	ND
Benzo(b)fluoranthene	8270	3.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	3.0	ND	ND	ND
Benzo(k)fluoranthene	8270	3.0	ND	ND	ND
Benzidine	8270	4.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	4.0	ND	ND	ND
N-Nitrosodimethylamine	8270	4.0	ND	ND	ND
Acenaphthene	8270	2.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	3.0	ND	ND	ND
4-Chloroaniline	8270	2.0	ND	ND	ND
2-Methylnaphthalene	8270	2.0	ND	ND	ND
2-Nitroaniline	8270	5.0	ND	ND	ND
4-Nitroaniline	8270	5.0	ND	ND	ND
Dibenzofuran	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2A. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Phenol	8270	2.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	2.0	ND	ND	NN
2-Chlorophenol	8270	2.0	ND	ND	ND
2,4-Dichlorophenol	8270	2.0	ND	ND	ND
2,4-Dimethylphenol	8270	2.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	5.0	ND	ND	ND
2,4-Dinitrophenol	8270	5.0	ND	ND	ND
2-Nitrophenol	8270	5.0	ND	ND	ND
4-Nitrophenol	8270	5.0	ND	ND	ND
p-Chloro-m-cresol	8270	2.0	ND	ND	ND
Pentachlorophenol	8270	5.0	ND	ND	ND
p-Cresol	8270	2.0	ND	ND	ND
o-Cresol	8270	2.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2A. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Azinphos-methyl	8140	0.10	ND	ND	ND
Bolstar (Sulprofos)	8140	0.07	ND	ND	ND
Coumaphos	8140	0.20	ND	ND	ND
Demeton, -O, -S	8140	0.12	ND	ND	ND
Diazinon	8140	0.20	ND	ND	ND
Dichlorvos	8140	0.80	ND	ND	ND
Dimethoate	8140	0.26	ND	ND	ND
Disulfoton	8140	0.07	ND	ND	ND
EPN	8140	0.04	ND	ND	ND
Ethoprop	8140	0.20	ND	ND	ND
Fensulfothion	8140	0.08	ND	ND	ND
Fenthion	8140	0.08	ND	ND	ND
Malathion	8140	0.11	ND	ND	ND
Merphos	8140	0.20	ND	ND	ND
Mevinphos	8140	0.50	ND	ND	ND
Naled	8140	0.50	ND	ND	ND
Parathion	8140	0.12	ND	ND	ND
Phorate	8140	0.04	ND	ND	ND
Ronnel	8140	0.07	ND	ND	ND
Sulfotep	8140	0.07	ND	ND	ND
TEPP	8140	0.80	ND	ND	ND
Tetrachlorovinphos	8140	0.80	ND	ND	ND
Tokuthion	8140	0.07	ND	ND	ND
Trichloronate	8140	0.80	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2A. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C	100% APG-EA
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Dursban	8080	0.0044	ND	ND	ND
Herbicides:					
2,4-D	8051?	1.5	ND	ND	ND
2,4,5-TP	8051?	0.05	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2B. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY CHRONIC HISTOPATHOLOGY GROUNDWATER EXPOSURE AQUARIA DILUTED WITH APG-EA TAP WATER (TEST NO. 2) - GENERAL WATER QUALITY[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Alkalinity ($CaCO_3$)	310.1	1.0	21.4	29.2	30.8
Ammonia Nitrogen (N)	350.3	0.01	0.084	0.084	0.097
Bromide	320.1	0.2	<0.2	<0.2	<0.2
Chloride (Cl)	508	1.0	36.0	25.4	23.4
Cyanide (Cn)	335.2	0.002	<0.005	<0.005	<0.005
Fluoride (F)	340.2	0.01	0.686	0.828	0.853
Hardness ($CaCO_3$)	AA	_	63.4	64.2	65.4
pH (electrometric)	150.1	_	6.60	6.75	6.92
Nitrate (N)	ISE	0.01	2.24	2.34	2.41
Nitrite (N)	354.1	0.001	<0.001	<0.001	<0.001
Phosphate (P)	365.3	0.01	0.483	0.319	0.364
Specific Conductance @ 25 °C	120.1	1.0	208	176	177
Sulfate (SO_4)	375.3	1.0	40.0	28.2	22.2
Sulfide (H_2S)	376.1	0.02	<0.02	<0.02	<0.02
Total Organic Carbon	415.1	2.0	<2.0	<2.0	<2.0
Total Suspended Solids	160.2	1.0	1.5	<1.0	<1.0

[a] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-2B. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Aluminum (Al)	200.7	25.6	677	250	259
Antimony (Sb)	200.7	14.1	<14.1	<14.1	<14.1
Arsenic (As)	200.7	45	<45	<45	<45
Beryllium (Be)	200.7	0.5	<0.5	<0.5	<0.5
Boron	200.7	10	474	455	468
Cadmium (Cd)	200.7	1.5	<1.5	<1.5	<1.5
Calcium (Ca)	200.7	30.6	17800	18200	18600
Chromium (Cr)	200.7	6	<6	<6	<6
Cobalt	200.7	1.3	11.4	1.9	<1.3
Copper (Cu)	200.7	3	36.1	35.0	35.6
Iron	200.7	2.5	25.5	33.8	33.5
Lead (Pb)	200.7	14.5	<14.5	<14.5	<14.5
Magnesium (Mg)	200.7	29.5	5410	5350	5390
Manganese (Mn)	200.7	0.97	205	41.4	12.3
Mercury (Hg)	245.1	0.1	<0.1	<0.1	<0.1
Molybdenum (Mo)	200.7	28.9	<28.9	<28.9	<28?
Nickel (Ni)	200.7	2.9	9.2	6.6	1.8?
Potassium (K)	200.7	40	2960	3290	3250
Selenium (Se)	200.7	11.1	<11.1	<11.1	<11.1
Silver (Ag)	200.7	6.7	<13.6	<13.6	<13.6
Sodium (Na)	200.7	30	<2700?	12400	10700
Thallium	200.7	75	<75	<75	<75
Tin (Sn)	200.7	9.7	<9.7	<9.7	<9.7
Zinc (Zn)	200.7	1.5	230	251	257

[a] All results expressed as μg/L.

TABLE A1-2B. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	ND	ND	ND
Bromodichloromethane	8021	0.5	12.9	2.1	3.6
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	8.9	2.4	ND
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	1.2	1.2	1.1
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	24.2	18.8	18.6
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	ND	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2B. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W	1% G.W.
cis-1,2-Dichloroethene	8021	0.5	ND	ND	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	8.6	1.2	ND
Tetrachloroethene	8021	0.5	0.8	ND	ND
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	ND	ND	ND
1,1,2-Trichloroethane	8021	0.5	ND	ND	ND
Trichloroethene	8021	0.5	11.9	ND	ND
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2B. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Bis-(2-chloroethoxy) Methane	8270	2.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	2.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	2.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	2.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	2.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	2.0	ND	ND	ND
2-Chloronapthalene	8270	2.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	2.0	ND	ND	ND
Chrysene	8270	2.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	3.0	ND	ND	ND
Acenaphthylene	8270	2.0	ND	ND	ND
1,2-Dichlorobenzene	8270	2.0	ND	ND	ND
1,3-Dichlorobenzene	8270	2.0	ND	ND	ND
1,4-Dichlorobenzene	8270	2.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	5.0	ND	ND	ND
Diethyl Phthalate	8270	2.0	ND	ND	ND
Dimethyl Phthalate	8270	5.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	2.0	ND	ND	ND
2,4-Dinitrotoluene	8270	4.0	ND	ND	ND
2,6-Dinitrotoluene	8270	4.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	2.0	ND	ND	ND
Fluoranthene	8270	2.0	ND	ND	ND
Fluorene	8270	2.0	ND	ND	ND
Hexachlorobenzene	8270	2.0	ND	ND	ND
Hexachlorobutadiene	8270	3.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	5.0	ND	ND	ND
Hexachloroethane	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2B. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Indeno[1,2,3-cd]pyrene	8270	3.0	ND	ND	ND
Isophorone	8270	2.0	ND	ND	ND
Naphthalene	8270	2.0	ND	ND	ND
Anthracene	8270	2.0	ND	ND	ND
Nitrobenzene	8270	4.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	4.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	4.0	ND	ND	ND
Phenanthrene	8270	2.0	ND	ND	ND
Pyrene	8270	2.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	2.0	ND	ND	ND
Benzo(a)anthracene	8270	3.0	ND	ND	ND
Benzo(a)pyrene	8270	3.0	ND	ND	ND
Benzo(b)fluoranthene	8270	3.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	3.0	ND	ND	ND
Benzo(k)fluoranthene	8270	3.0	ND	ND	ND
Benzidine	8270	4.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	4.0	ND	ND	ND
N-Nitrosodimethylamine	8270	4.0	ND	ND	ND
Acenaphthene	8270	2.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	3.0	ND	ND	ND
4-Chloroaniline	8270	2.0	ND	ND	ND
2-Methylnaphthalene	8270	2.0	ND	ND	ND
2-Nitroaniline	8270	5.0	ND	ND	ND
4-Nitroaniline	8270	5.0	ND	ND	ND
Dibenzofuran	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2B. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Phenol	8270	2.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	2.0	ND	ND	ND
2-Chlorophenol	8270	2.0	ND	ND	ND
2,4-Dichlorophenol	8270	2.0	ND	ND	ND
2,4-Dimethylphenol	8270	2.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	5.0	ND	ND	ND
2,4-Dinitrophenol	8270	5.0	ND	ND	ND
2-Nitrophenol	8270	5.0	ND	ND	ND
4-Nitrophenol	8270	5.0	ND	ND	ND
p-Chloro-m-cresol	8270	2.0	ND	ND	ND
Pentachlorophenol	8270	5.0	ND	ND	ND
p-Cresol	8270	2.0	ND	ND	ND
o-Cresol	8270	2.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2B. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Azinphos-methyl	8140	0.10	ND	ND	ND
Bolstar (Sulprofos)	8140	0.07	ND	ND	ND
Coumaphos	8140	0.20	ND	ND	ND
Demeton, -O, -S	8140	0.12	ND	ND	ND
Diazinon	8140	0.20	ND	ND	ND
Dichlorvos	8140	0.80	ND	ND	ND
Dimethoate	8140	0.26	ND	ND	ND
Disulfoton	8140	0.07	ND	ND	ND
EPN	8140	0.04	ND	ND	ND
Ethoprop	8140	0.20	ND	ND	ND
Fensulfothion	8140	0.08	ND	ND	ND
Fenthion	8140	0.08	ND	ND	ND
Malathion	8140	0.11	ND	ND	ND
Merphos	8140	0.20	ND	ND	ND
Mevinphos	8140	0.50	ND	ND	ND
Naled	8140	0.50	ND	ND	ND
Parathion	8140	0.12	ND	ND	ND
Phorate	8140	0.04	ND	ND	ND
Ronnel	8140	0.07	ND	ND	ND
Sulfotep	8140	0.07	ND	ND	ND
TEPP	8140	0.80	ND	ND	ND
Tetrachlorovinphos	8140	0.80	ND	ND	ND
Tokuthion	8140	0.07	ND	ND	ND
Trichloronate	8140	0.80	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2B. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Dursban	8080	0.0044	ND	ND	ND
Herbicides:					
2,4-D	8051?	1.5	ND	ND	ND
2,4,5-TP	8051?	0.05	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2C. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY CHRONIC HISTOPATHOLOGY GROUNDWATER EXPOSURE AQUARIA DILUTED WITH WEST BRANCH OF CANAL CREEK WATER (TEST NO. 2) - GENERAL WATER QUALITY[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Alkalinity ($CaCO_3$)	310.1	1.0	38.4	50.8	51.8
Ammonia Nitrogen (N)	350.3	0.01	0.218	0.238	0.249
Bromide	320.1	0.2	<0.2	<0.2	<0.2
Chloride (Cl)	508	1.0	273	323	358
Cyanide (Cn)	335.2	0.002	<0.005	<0.005	<0.005
Fluoride (F)	340.2	0.01	0.204	0.188	0.189
Hardness ($CaCO_3$)	AA	_	126	141	150
pH (electrometric)	150.1	_	6.28	6.61	6.69
Nitrate (N)	ISE	0.01	1.73	1.67	1.65
Nitrite (N)	354.1	0.001	0.008	0.019	0.03
Phosphate (P)	365.3	0.01	0.565	0.601	0.930
Specific Conductance @ 25 °C	120.1	1.0	776	854	875
Sulfate (SO_4)	375.3	1.0	63.2	53.4	57.0
Sulfide (H_2S)	376.1	0.02	<0.02	<0.02	<0.02
Total Organic Carbon	415.1	2.0	3.7	3.8	9.6
Total Suspended Solids	160.2	1.0	18	20.7	20.1

[a] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-2C. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W
Aluminum (Al)	200.7	25.6	851	564	545
Antimony (Sb)	200.7	14.1	<14.1	<14.1	<14.1
Arsenic (As)	200.7	45	<45	<45	<45
Beryllium (Be)	200.7	0.5	<0.5	<0.5	<0.5
Boron	200.7	10	439	472	498
Cadmium (Cd)	200.7	1.5	<1.5	<1.5	<1.5
Calcium (Ca)	200.7	30.6	21300	22600	23400
Chromium (Cr)	200.7	6	<6	6.9	6.2
Cobalt	200.7	1.3	13.6	5.8	5.2
Copper (Cu)	200.7	3	14.9	16.9	15.4
Iron	200.7	2.5	1470	1880	1870
Lead (Pb)	200.7	14.5	<14.5	<14.5	<14.5
Magnesium (Mg)	200.7	29.5	20700	24100	26300
Manganese (Mn)	200.7	0.97	806	746	671
Mercury (Hg)	245.1	0.1	<0.1	<0.1	<0.1
Molybdenum (Mo)	200.7	28.9	<28.9	<28.9	<28.9
Nickel (Ni)	200.7	2.9	12.8	11.3	14.7
Potassium (K)	200.7	40	10600	7310	8180
Selenium (Se)	200.7	11.1	<11.1	<11.1	<11.1
Silver (Ag)	200.7	6.7	<13.6	<13.6	<13.6
Sodium (Na)	200.7	30	81200	169000	188000
Thallium	200.7	75	<75	<75	<75
Tin (Sn)	200.7	9.7	<9.7	<9.7	<9.7
Zinc (Zn)	200.7	1.5	77.0	76.7	88.4

[a] All results expressed as μg/L.

TABLE A1-2C. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	ND	ND	ND
Bromodichloromethane	8021	0.5	11.9	2.5	0.9
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	11.3	6.6	5.7
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	ND
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	13.2	4.7	3.3
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	ND	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2C. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
cis-1,2-Dichloroethene	8021	0.5	ND	ND	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	9.6	3.4	2.6
Tetrachloroethene	8021	0.5	1.9	1.2	1.2
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	ND	ND	ND
1,1,2-Trichloroethane	8021	0.5	ND	ND	ND
Trichloroethene	8021	0.5	11.0	3.4	1.5
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2C. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Bis-(2-chloroethoxy) Methane	8270	2.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	2.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	2.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	2.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	2.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	2.0	ND	ND	ND
2-Chloronapthalene	8270	2.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	2.0	ND	ND	ND
Chrysene	8270	2.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	3.0	ND	ND	ND
Acenaphthylene	8270	2.0	ND	ND	ND
1,2-Dichlorobenzene	8270	2.0	ND	ND	ND
1,3-Dichlorobenzene	8270	2.0	ND	ND	ND
1,4-Dichlorobenzene	8270	2.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	5.0	ND	ND	ND
Diethyl Phthalate	8270	2.0	ND	ND	ND
Dimethyl Phthalate	8270	5.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	2.0	ND	ND	ND
2,4-Dinitrotoluene	8270	4.0	ND	ND	ND
2,6-Dinitrotoluene	8270	4.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	2.0	ND	ND	ND
Fluoranthene	8270	2.0	ND	ND	ND
Fluorene	8270	2.0	ND	ND	ND
Hexachlorobenzene	8270	2.0	ND	ND	ND
Hexachlorobutadiene	8270	3.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	5.0	ND	ND	ND
Hexachloroethane	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2C. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Indeno[1,2,3-cd]pyrene	8270	3.0	ND	ND	ND
Isophorone	8270	2.0	ND	ND	ND
Naphthalene	8270	2.0	ND	ND	ND
Anthracene	8270	2.0	ND	ND	ND
Nitrobenzene	8270	4.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	4.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	4.0	ND	ND	ND
Phenanthrene	8270	2.0	ND	ND	ND
Pyrene	8270	2.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	2.0	ND	ND	ND
Benzo(a)anthracene	8270	3.0	ND	ND	ND
Benzo(a)pyrene	8270	3.0	ND	ND	ND
Benzo(b)fluoranthene	8270	3.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	3.0	ND	ND	ND
Benzo(k)fluoranthene	8270	3.0	ND	ND	ND
Benzidine	8270	4.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	4.0	ND	ND	ND
N-Nitrosodimethylamine	8270	4.0	ND	ND	ND
Acenaphthene	8270	2.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	3.0	ND	ND	ND
4-Chloroaniline	8270	2.0	ND	ND	ND
2-Methylnaphthalene	8270	2.0	ND	ND	ND
2-Nitroaniline	8270	5.0	ND	ND	ND
4-Nitroaniline	8270	5.0	ND	ND	ND
Dibenzofuran	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2C. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Phenol	8270	2.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	2.0	ND	ND	ND
2-Chlorophenol	8270	2.0	ND	ND	ND
2,4-Dichlorophenol	8270	2.0	ND	ND	ND
2,4-Dimethylphenol	8270	2.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	5.0	ND	ND	ND
2,4-Dinitrophenol	8270	5.0	ND	ND	ND
2-Nitrophenol	8270	5.0	ND	ND	ND
4-Nitrophenol	8270	5.0	ND	ND	ND
p-Chloro-m-cresol	8270	2.0	ND	ND	ND
Pentachlorophenol	8270	5.0	ND	ND	ND
p-Cresol	8270	2.0	ND	ND	ND
o-Cresol	8270	2.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	2.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2C. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Azinphos-methyl	8140	0.10	ND	ND	ND
Bolstar (Sulprofos)	8140	0.07	ND	ND	ND
Coumaphos	8140	0.20	ND	ND	ND
Demeton, -O, -S	8140	0.12	ND	ND	ND
Diazinon	8140	0.20	ND	ND	ND
Dichlorvos	8140	0.80	ND	ND	ND
Dimethoate	8140	0.26	ND	ND	ND
Disulfoton	8140	0.07	ND	ND	ND
EPN	8140	0.04	ND	ND	ND
Ethoprop	8140	0.20	ND	ND	ND
Fensulfothion	8140	0.08	ND	ND	ND
Fenthion	8140	0.08	ND	ND	ND
Malathion	8140	0.11	ND	ND	ND
Merphos	8140	0.20	ND	ND	ND
Mevinphos	8140	0.50	ND	ND	ND
Naled	8140	0.50	ND	ND	ND
Parathion	8140	0.12	ND	ND	ND
Phorate	8140	0.04	ND	ND	ND
Ronnel	8140	0.07	ND	ND	ND
Sulfotep	8140	0.07	ND	ND	ND
TEPP	8140	0.80	ND	ND	ND
Tetrachlorovinphos	8140	0.80	ND	ND	ND
Tokuthion	8140	0.07	ND	ND	ND
Trichloronate	8140	0.80	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-2C. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Dursban	8080	0.0044	ND	ND	ND
Herbicides:					
2,4-D	8051?	1.5	ND	ND	ND
2,4,5-TP	8051?	0.05	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3A. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY GROUNDWATER (WELL NO. CC-27B), WEST BRANCH OF CANAL CREEK SURFACE WATER, AND APG-EA TAP WATER (TEST NO. 3) - GENERAL WATER QUALITY[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Alkalinity ($CaCO_3$)	310.1	1.0	0?	38.0	90.4
Ammonia Nitrogen (N)	350.3	0.01	0.011	0.095	0.01
Bromide	320.1	0.2	<0.2	<0.2	<0.2
Chloride (Cl)	325.3	1.0	147	62.4	16.6
Cyanide (Cn)	335.2	0.002	<0.002	<0.002	<0.002
Fluoride (F)	340.2	0.01	0.264	0.102	0.349
Hardness ($CaCO_3$)	AA	_	58.0	72.6	53.5
pH (electrometric)	150.1	0.01	4.20	6.59	8.12
Nitrate (N)	ISE	0.01	1.76	1.37	5.64
Nitrite (N)	354.1	0.001	<0.001	0.011	<0.001
Phosphate (P)	365.3	0.1	0.932	0.252	0.260
Specific Conductance @ 25 °C	120.1	1.0	423	324	274
Sulfate (SO_4)	375.3	1.0	99.5	46.8	29.6
Sulfide (H_2S)	9030	0.002	<0.002	<0.002	<0.002
Total Organic Carbon	415.1	2.0	<2.0	6.5	<2.0
Total Suspended Solids	160.2	1.0	<1.0	22.1	<1.0

[a] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-3A. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Aluminum (Al)	200.7	10	1660	622	63.0
Antimony (Sb)	204.2	14.5	<14.5		<14.5
	200.7	14.5		<14.5	
Arsenic (As)	200.7	45	<45	<45	<45
Beryllium (Be)	200.7	0.5	1.5	<0.5	<0.5
Boron	200.7	50	57.2	57.1	<50
Cadmium (Cd)	200.7	1.5	<1.5	<1.5	<1.5
Calcium (Ca)	200.7	32.6	15700	16400	14400
Chromium (Cr)	200.7	6	<6	<6	<6
Cobalt	200.7	1.3	41.7	3.8	<1.3
Copper (Cu)	200.7	2.5	10.2	4.7	23.6
Iron	200.7	2.5	19.7	1440	38.4
Lead (Pb)	200.7	14.5	<14.5	<14.5	<14.5
Magnesium (Mg)	200.7	29	5360	9030	5000
Manganese (Mn)	200.7	0.97	639	212	1.4
Mercury (Hg)	245.1	0.1	<0.1	<0.1	<0.1
Molybdenum (Mo)	200.7	30	52.8	116	89.9
Nickel (Ni)	200.7	2.9	22.2	10.0	3.9
Potassium (K)	200.7	50	2140	3280	2270
Selenium (Se)	200.7	11.1		<11.1	
	270.2	11.1	<11.1		<11.1
Silver (Ag)	200.7	9	46.8	<9	<9
Sodium (Na)	200.7	50	56900	35000	41800
Thallium	200.7	75	<75	<75	<75
Tin (Sn)	200.7	9.7	<9.7	<9.7	<9.7
Zinc (Zn)	200.7	1.5	57.5	69.9	45.7

[a] All results expressed as μg/L.

TABLE A1-3A. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	ND	ND	ND
Bromodichloromethane	8021	0.5	68.4	ND	ND
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	32.8	4.1	ND
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	ND
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	55.9	4.4	2.9
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	2.1	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3A. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
cis-1,2-Dichloroethene	8021	0.5	2.4	ND	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	53.8	ND	ND
Tetrachloroethene	8021	0.5	5.2	ND	ND
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	ND	ND	ND
1,1,2-Trichloroethane	8021	0.5	ND	ND	ND
Trichloroethene	8021	0.5	85.0	ND	ND
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as $\mu g/L$.

TABLE A1-3A. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Bis-(2-chloroethoxy) Methane	8270	10.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	10.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	10.0	ND	ND	ND
2-Chloronapthalene	8270	10.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Chrysene	8270	10.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	10.0	ND	ND	ND
Acenaphthylene	8270	10.0	ND	ND	ND
1,2-Dichlorobenzene	8270	10.0	ND	ND	ND
1,3-Dichlorobenzene	8270	10.0	ND	ND	ND
1,4-Dichlorobenzene	8270	10.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	20.0	ND	ND	ND
Diethyl Phthalate	8270	10.0	ND	ND	ND
Dimethyl Phthalate	8270	10.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	10.0	ND	ND	ND
2,4-Dinitrotoluene	8270	10.0	ND	ND	ND
2,6-Dinitrotoluene	8270	10.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	10.0	ND	ND	ND
Fluoranthene	8270	10.0	ND	ND	ND
Fluorene	8270	10.0	ND	ND	ND
Hexachlorobenzene	8270	10.0	ND	ND	ND
Hexachlorobutadiene	8270	10.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	10.0	ND	ND	ND
Hexachloroethane	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3A. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Indeno[1,2,3-cd]pyrene	8270	10.0	ND	ND	ND
Isophorone	8270	10.0	ND	ND	ND
Naphthalene	8270	10.0	ND	ND	ND
Anthracene	8270	10.0	ND	ND	ND
Nitrobenzene	8270	10.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	10.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	10.0	ND	ND	ND
Phenanthrene	8270	10.0	ND	ND	ND
Pyrene	8270	10.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	10.0	ND	ND	ND
Benzo(a)anthracene	8270	10.0	ND	ND	ND
Benzo(a)pyrene	8270	10.0	ND	ND	ND
Benzo(b)fluoranthene	8270	10.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	10.0	ND	ND	ND
Benzo(k)fluoranthene	8270	10.0	ND	ND	ND
Benzidine	8270	10.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	20.0	ND	ND	ND
N-Nitrosodimethylamine	8270	20.0	ND	ND	ND
Acenaphthene	8270	10.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	10.0	ND	ND	ND
4-Chloroaniline	8270	20.0	ND	ND	ND
2-Methylnaphthalene	8270	10.0	ND	ND	ND
2-Nitroaniline	8270	50.0	ND	ND	ND
4-Nitroaniline	8270	20.0	ND	ND	ND
Dibenzofuran	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3A. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Phenol	8270	10.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	10.0	ND	ND	ND
2-Chlorophenol	8270	10.0	ND	ND	ND
2,4-Dichlorophenol	8270	10.0	ND	ND	ND
2,4-Dimethylphenol	8270	10.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	50.0	ND	ND	ND
2,4-Dinitrophenol	8270	50.0	ND	ND	ND
2-Nitrophenol	8270	10.0	ND	ND	ND
4-Nitrophenol	8270	50.0	ND	ND	ND
p-Chloro-m-cresol	8270	20.0	ND	ND	ND
Pentachlorophenol	8270	50.0	ND	ND	ND
p-Cresol	8270	10.0	ND	ND	ND
o-Cresol	8270	10.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3A. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Azinphos-methyl	8140	0.20	ND	ND	ND
Bolstar (Sulprofos)	8140	0.14	ND	ND	ND
Coumaphos	8140	0.40	ND	ND	ND
Demeton, -O, -S	8140	0.24	ND	ND	ND
Diazinon	8140	0.40	ND	ND	ND
Dichlorvos	8140	1.60	ND	ND	ND
Dimethoate	8140	0.52	ND	ND	ND
Disulfoton	8140	0.14	ND	ND	ND
EPN	8140	0.08	ND	ND	ND
Ethoprop	8140	0.40	ND	ND	ND
Fensulfothion	8140	0.16	ND	ND	ND
Fenthion	8140	0.16	ND	ND	ND
Malathion	8140	0.22	ND	ND	ND
Merphos	8140	0.40	ND	ND	ND
Mevinphos	8140	1.00	ND	ND	ND
Naled	8140	1.00	ND	ND	ND
Parathion	8140	0.24	ND	ND	ND
Phorate	8140	0.08	ND	ND	ND
Ronnel	8140	0.14	ND	ND	ND
Sulfotep	8140	0.14	ND	ND	ND
TEPP	8140	1.60	ND	ND	ND
Tetrachlorovinphos	8140	1.60	ND	ND	ND
Tokuthion	8140	0.14	ND	ND	ND
Trichloronate	8140	1.60	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3A. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C	100% APG-EA
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Dursban	8080	0.0044	ND	ND	ND
Herbicides:					
2,4-D	8150	1.5	ND	ND	ND
2,4,5-TP	8150	0.05	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3B. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY CHRONIC HISTOPATHOLOGY GROUNDWATER EXPOSURE AQUARIA DILUTED WITH APG-EA TAP WATER (TEST NO. 3) - GENERAL WATER QUALITY[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Alkalinity ($CaCO_3$)	310.1	1.0	69	90	94.4
Ammonia Nitrogen (N)	350.3	0.01	0.046	0.047	0.045
Bromide	320.1	0.2	<0.2	<0.2	<0.2
Chloride (Cl)	325.3	1.0	28.8	18.0	16.8
Cyanide (Cn)	335.2	0.002	<0.002	<0.002	<0.002
Fluoride (F)	340.2	0.01	0.293	0.313	0.318
Hardness ($CaCO_3$)	AA	_	54.4	52.4	52.9
pH (electrometric)	150.1	0.01	6.97	7.52	7.88
Nitrate (N)	ISE	0.01	4.90	5.76	5.85
Nitrite (N)	354.1	0.001	<0.001	<0.001	<0.001
Phosphate (P)	365.3	0.1	0.406	0.368	0.251
Specific Conductance @ 25 °C	120.1	1.0	309	299	291
Sulfate (SO_4)	375.3	1.0	46.2	30.2	25.6
Sulfide (H_2S)	9030	0.002	<0.002	<0.002	<0.002
Total Organic Carbon	415.1	2.0	<2.0	<2.0	<2.0
Total Suspended Solids	160.2	1.0	2.4	2.8	<1.0

[a] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-3B. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Aluminum (Al)	200.7	100?	410		
		10		160	95.3
Antimony (Sb)	204.2	14.5	<14.5	<14.5	<14.5
Arsenic (As)	200.7	45	<45	<45	<45
Beryllium (Be)	200.7	0.5	0.6	<0.5	<0.5
Boron	200.7	50	<50	<50	<50
Cadmium (Cd)	200.7	1.5	<1.5	<1.5	<1.5
Calcium (Ca)	200.7	32.6	14600	14000	14100
Chromium (Cr)	200.7	6	<6	<6	<6
Cobalt	200.7	1.3	10.5	<1.3	<1.3
Copper (Cu)	200.7	2.5	23.4	20.2	19.0
Iron	200.7	2.5	26.3	18.5	18.2
Lead (Pb)	200.7	14.5	<14.5	<14.5	<14.5
Magnesium (Mg)	200.7	29	5120	4980	5030
Manganese (Mn)	200.7	0.97	157	30.9	7.1
Mercury (Hg)	245.1	0.1	<0.1	<0.1	<0.1
Molybdenum (Mo)	200.7	30	116	80.2	83.3
Nickel (Ni)	200.7	2.9	10.2	5.9	4.8
Potassium (K)	200.7	50	2260	2230	2340
Selenium (Se)	270.2	11.1	<11.1	<11.1	<11.1
Silver (Ag)	200.7	9	9.6	<9	<9
Sodium (Na)	200.7	50	48000	44600	45600
Thallium	200.7	75	<75	<75	<75
Tin (Sn)	200.7	9.7	<9.7	<9.7	<9.7
Zinc (Zn)	200.7	1.5	48.2	48.3	46.6

[a] All results expressed as μg/L.

TABLE A1-3B. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	ND	ND	ND
Bromodichloromethane	8021	0.5	12.7	1.0	ND
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	4.3	ND	ND
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	ND
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	10.9	3.8	2.0
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	ND	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3B. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
cis-1,2-Dichloroethene	8021	0.5	ND	ND	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	12.9	2.5	ND
Tetrachloroethene	8021	0.5	ND	ND	ND
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	ND	ND	ND
1,1,2-Trichloroethane	8021	0.5	ND	ND	ND
Trichloroethene	8021	0.5	12.7	2.4	ND
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3B. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Bis-(2-chloroethoxy) Methane	8270	10.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	10.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	10.0	ND	ND	ND
2-Chloronapthalene	8270	10.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Chrysene	8270	10.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	10.0	ND	ND	ND
Acenaphthylene	8270	10.0	ND	ND	ND
1,2-Dichlorobenzene	8270	10.0	ND	ND	ND
1,3-Dichlorobenzene	8270	10.0	ND	ND	ND
1,4-Dichlorobenzene	8270	10.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	20.0	ND	ND	ND
Diethyl Phthalate	8270	10.0	ND	ND	ND
Dimethyl Phthalate	8270	10.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	10.0	ND	ND	ND
2,4-Dinitrotoluene	8270	10.0	ND	ND	ND
2,6-Dinitrotoluene	8270	10.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	10.0	ND	ND	ND
Fluoranthene	8270	10.0	ND	ND	ND
Fluorene	8270	10.0	ND	ND	ND
Hexachlorobenzene	8270	10.0	ND	ND	ND
Hexachlorobutadiene	8270	10.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	10.0	ND	ND	ND
Hexachloroethane	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3B. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Indeno[1,2,3-cd]pyrene	8270	10.0	ND	ND	ND
Isophorone	8270	10.0	ND	ND	ND
Naphthalene	8270	10.0	ND	ND	ND
Anthracene	8270	10.0	ND	ND	ND
Nitrobenzene	8270	10.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	10.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	10.0	ND	ND	ND
Phenanthrene	8270	10.0	ND	ND	ND
Pyrene	8270	10.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	10.0	ND	ND	ND
Benzo(a)anthracene	8270	10.0	ND	ND	ND
Benzo(a)pyrene	8270	10.0	ND	ND	ND
Benzo(b)fluoranthene	8270	10.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	10.0	ND	ND	ND
Benzo(k)fluoranthene	8270	10.0	ND	ND	ND
Benzidine	8270	10.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	20.0	ND	ND	ND
N-Nitrosodimethylamine	8270	20.0	ND	ND	ND
Acenaphthene	8270	10.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	10.0	ND	ND	ND
4-Chloroaniline	8270	20.0	ND	ND	ND
2-Methylnaphthalene	8270	10.0	ND	ND	ND
2-Nitroaniline	8270	50.0	ND	ND	ND
4-Nitroaniline	8270	20.0	ND	ND	ND
Dibenzofuran	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3B. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Phenol	8270	10.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	10.0	ND	ND	ND
2-Chlorophenol	8270	10.0	ND	ND	ND
2,4-Dichlorophenol	8270	10.0	ND	ND	ND
2,4-Dimethylphenol	8270	10.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	50.0	ND	ND	ND
2,4-Dinitrophenol	8270	50.0	ND	ND	ND
2-Nitrophenol	8270	10.0	ND	ND	ND
4-Nitrophenol	8270	50.0	ND	ND	ND
p-Chloro-m-cresol	8270	20.0	ND	ND	ND
Pentachlorophenol	8270	50.0	ND	ND	ND
p-Cresol	8270	10.0	ND	ND	ND
o-Cresol	8270	10.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3B. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Azinphos-methyl	8140	0.20	ND	ND	ND
Bolstar (Sulprofos)	8140	0.14	ND	ND	ND
Coumaphos	8140	0.40	ND	ND	ND
Demeton, -O, -S	8140	0.24	ND	ND	ND
Diazinon	8140	0.40	ND	ND	ND
Dichlorvos	8140	1.60	ND	ND	ND
Dimethoate	8140	0.52	ND	ND	ND
Disulfoton	8140	0.14	ND	ND	ND
EPN	8140	0.08	ND	ND	ND
Ethoprop	8140	0.40	ND	ND	ND
Fensulfothion	8140	0.16	ND	ND	ND
Fenthion	8140	0.16	ND	ND	ND
Malathion	8140	0.22	ND	ND	ND
Merphos	8140	0.40	ND	ND	ND
Mevinphos	8140	1.00	ND	ND	ND
Naled	8140	1.00	ND	ND	ND
Parathion	8140	0.24	ND	ND	ND
Phorate	8140	0.08	ND	ND	ND
Ronnel	8140	0.14	ND	ND	ND
Sulfotep	8140	0.14	ND	ND	ND
TEPP	8140	1.60	ND	ND	ND
Tetrachlorovinphos	8140	1.60	ND	ND	ND
Tokuthion	8140	0.14	ND	ND	ND
Trichloronate	8140	1.60	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3B. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Dursban	8080	0.0044	ND	ND	ND
Herbicides:					
2,4-D	8150	1.5	ND	ND	ND
2,4,5-TP	8150	0.05	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3C. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY CHRONIC HISTOPATHOLOGY GROUNDWATER EXPOSURE AQUARIA DILUTED WITH WEST BRANCH OF CANAL CREEK WATER (TEST NO. 3) - GENERAL WATER QUALITY[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Alkalinity ($CaCO_3$)	310.1	1.0	27.6	35.6	35.8
Ammonia Nitrogen (N)	350.3	0.01	0.103	0.086	0.087
Bromide	320.1	0.2	<0.2	<0.2	<0.2
Chloride (Cl)	325.3	1.0	64.8	64.0	63.2
Cyanide (Cn)	335.2	0.002	<0.002	<0.002	<0.002
Fluoride (F)	340.2	0.01	0.114	0.129	0.113
Hardness ($CaCO_3$)	AA	_	67.2	70.5	70.5
pH (electrometric)	150.1	0.01	6.48	6.73	6.81
Nitrate (N)	ISE	0.01	1.43	1.39	1.43
Nitrite (N)	354.1	0.001	0.002	0.004	0.008
Phosphate (P)	365.3	0.1	0.304	0.824	0.592
Specific Conductance @ 25 °C	120.1	1.0	348	320	310
Sulfate (SO_4)	375.3	1.0	32.8	44.4	44.0
Sulfide (H_2S)	9030	0.002	<0.002	<0.002	<0.002
Total Organic Carbon	415.1	2.0	<2.0	<2.0	<2.0
Total Suspended Solids	160.2	1.0	15.2	17.4	20.1

[a] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-3C. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Aluminum (Al)	200.7	10	1030	889	711
Antimony (Sb)	204.2	14.5	<14.5	<14.5	<14.5
Arsenic (As)	206.2	45	<45		
	200.7	45		<45	
	200.2	45			<45
Beryllium (Be)	200.7	0.5	0.7	<0.5	<0.5
Boron	200.7	50	<50	<50	<50
Cadmium (Cd)	213.1	1.5	<1.5		
	200.7	1.5		<1.5	<1.5
Calcium (Ca)	200.7	32.6	15900	16100	16000
Chromium (Cr)	218.1	1	<1		
	200.7	6		<6	<6
Cobalt	200.7	1.3	13.4	5.9	4.2
Copper (Cu)	200.7	2.5	7.8	7.3	6.6
Iron	200.7	2.5	1240	1520	1490
Lead (Pb)	239.2	14.5	<14.5		
	200.7	14.5		<14.5	<14.5
Magnesium (Mg)	200.7	29	7830	8640	8700
Manganese (Mn)	200.7	0.97	350	238	220
Mercury (Hg)	245.1	0.1	<0.1	<0.1	<0.1
Molybdenum (Mo)	246.1	30	109		
	200.7	30		108	102
Nickel (Ni)	200.7	2.9	16	9	10.8
Potassium (K)	200.7	50	3130	3250	3290
Selenium (Se)	270.2	11.1	<11.1	<11.1	<11.1
Silver (Ag)	200.7	9	<9	<9	<9

[a] All results expressed as μg/L.

TABLE A1-3C. (CONTINUED) - METALS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Sodium (Na)	200.7	50	41800	37300	35900
Thallium	279.2	75	<75		
	200.7	75		<75	<75
Tin (Sn)	200.7	9.7	<9.7	<9.7	<9.7
Zinc (Zn)	200.7	1.5	80.5	68.3	72.6

[a] All results expressed as μg/L.

TABLE A1-3C. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	ND	ND	ND
Bromodichloromethane	8021	0.5	15.4	3.8	1.1
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	8.8	4.8	3.9
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	ND
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	14.8	6.1	4.5
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	ND	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3C. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
cis-1,2-Dichloroethene	8021	0.5	ND	ND	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	17.8	7.9	5.9
Tetrachloroethene	8021	0.5	1.3	0.9	0.8
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	ND	ND	ND
1,1,2-Trichloroethane	8021	0.5	ND	ND	ND
Trichloroethene	8021	0.5	15.9	3.6	1.1
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as $\mu g/L$.

TABLE A1-3C. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Bis-(2-chloroethoxy) Methane	8270	10.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	10.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	10.0	ND	ND	ND
2-Chloronapthalene	8270	10.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Chrysene	8270	10.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	10.0	ND	ND	ND
Acenaphthylene	8270	10.0	ND	ND	ND
1,2-Dichlorobenzene	8270	10.0	ND	ND	ND
1,3-Dichlorobenzene	8270	10.0	ND	ND	ND
1,4-Dichlorobenzene	8270	10.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	20.0	ND	ND	ND
Diethyl Phthalate	8270	10.0	ND	ND	ND
Dimethyl Phthalate	8270	10.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	10.0	ND	ND	ND
2,4-Dinitrotoluene	8270	10.0	ND	ND	ND
2,6-Dinitrotoluene	8270	10.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	10.0	ND	ND	ND
Fluoranthene	8270	10.0	ND	ND	ND
Fluorene	8270	10.0	ND	ND	ND
Hexachlorobenzene	8270	10.0	ND	ND	ND
Hexachlorobutadiene	8270	10.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	10.0	ND	ND	ND
Hexachloroethane	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3C. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Indeno[1,2,3-cd]pyrene	8270	10.0	ND	ND	ND
Isophorone	8270	10.0	ND	ND	ND
Naphthalene	8270	10.0	ND	ND	ND
Anthracene	8270	10.0	ND	ND	ND
Nitrobenzene	8270	10.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	10.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	10.0	ND	ND	ND
Phenanthrene	8270	10.0	ND	ND	ND
Pyrene	8270	10.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	10.0	ND	ND	ND
Benzo(a)anthracene	8270	10.0	ND	ND	ND
Benzo(a)pyrene	8270	10.0	ND	ND	ND
Benzo(b)fluoranthene	8270	10.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	10.0	ND	ND	ND
Benzo(k)fluoranthene	8270	10.0	ND	ND	ND
Benzidine	8270	10.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	20.0	ND	ND	ND
N-Nitrosodimethylamine	8270	20.0	ND	ND	ND
Acenaphthene	8270	10.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	10.0	ND	ND	ND
4-Chloroaniline	8270	20.0	ND	ND	ND
2-Methylnaphthalene	8270	10.0	ND	ND	ND
2-Nitroaniline	8270	50.0	ND	ND	ND
4-Nitroaniline	8270	20.0	ND	ND	ND
Dibenzofuran	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3C. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Phenol	8270	10.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	10.0	ND	ND	ND
2-Chlorophenol	8270	10.0	ND	ND	ND
2,4-Dichlorophenol	8270	10.0	ND	ND	ND
2,4-Dimethylphenol	8270	10.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	50.0	ND	ND	ND
2,4-Dinitrophenol	8270	50.0	ND	ND	ND
2-Nitrophenol	8270	10.0	ND	ND	ND
4-Nitrophenol	8270	50.0	ND	ND	ND
p-Chloro-m-cresol	8270	20.0	ND	ND	ND
Pentachlorophenol	8270	50.0	ND	ND	ND
p-Cresol	8270	10.0	ND	ND	ND
o-Cresol	8270	10.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3C. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Azinphos-methyl	8140	0.20	ND	ND	ND
Bolstar (Sulprofos)	8140	0.14	ND	ND	ND
Coumaphos	8140	0.40	ND	ND	ND
Demeton, -O, -S	8140	0.24	ND	ND	ND
Diazinon	8140	0.40	ND	ND	ND
Dichlorvos	8140	1.60	ND	ND	ND
Dimethoate	8140	0.52	ND	ND	ND
Disulfoton	8140	0.14	ND	ND	ND
EPN	8140	0.08	ND	ND	ND
Ethoprop	8140	0.40	ND	ND	ND
Fensulfothion	8140	0.16	ND	ND	ND
Fenthion	8140	0.16	ND	ND	ND
Malathion	8140	0.22	ND	ND	ND
Merphos	8140	0.40	ND	ND	ND
Mevinphos	8140	1.00	ND	ND	ND
Naled	8140	1.00	ND	ND	ND
Parathion	8140	0.24	ND	ND	ND
Phorate	8140	0.08	ND	ND	ND
Ronnel	8140	0.14	ND	ND	ND
Sulfotep	8140	0.14	ND	ND	ND
TEPP	8140	1.60	ND	ND	ND
Tetrachlorovinphos	8140	1.60	ND	ND	ND
Tokuthion	8140	0.14	ND	ND	ND
Trichloronate	8140	1.60	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-3C. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Dursban	8080	0.0044	ND	ND	ND
Herbicides:					
2,4-D	8150	1.5	ND	ND	ND
2,4,5-TP	8150	0.05	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4A. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY GROUNDWATER (WELL NO. CC-27B), WEST BRANCH OF CANAL CREEK SURFACE WATER, AND APG-EA TAP WATER (TEST NO. 4) - GENERAL WATER QUALITY[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Alkalinity ($CaCO_3$)	310.1	1.0	0?	58.6	31.0
Ammonia Nitrogen (N)	350.3	0.01	0.014	0.203	0.071
Bromide	320.1	0.2	<0.2	<0.2	<0.2
Chloride (Cl)	325.3	1.0	74	165	27.0
Cyanide (Cn)	335.2	0.002	<0.006	<0.006	<0.006
Fluoride (F)	340.2	0.01	0.241	0.127	0.778
Hardness ($CaCO_3$)	AA	_	61.2	111	62.6
pH (electrometric)	150.1	0.01	3.62	6.12	7.15
Nitrate (N)	ISE	0.01	1.59	0.696	2.64
Nitrite (N)	354.1	0.001	<0.002	0.025	0.006
Phosphate (P)	365.3	0.1	1.32	0.148	0.312
Specific Conductance @ 25 °C	120.1	1.0	441	660	216
Sulfate (SO_4)	375.3	1.0	92.0	63.2	36.0
Sulfide (H_2S)	9030	0.002	<0.002	<0.002	<0.002
Total Organic Carbon	415.1	2.0	<2.0	5.5	<2.0
Total Suspended Solids	160.2	1.0	<1.0	16.5	1.1

[a] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-4A. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Aluminum (Al)	200.7	10	1790	455	80.4
Antimony (Sb)	204.2	50	<50	<50	<50
Arsenic (As)	200.7	3.2	<3.2	<3.2	<3.2
Beryllium (Be)	200.7	1	1	<1	<1
Boron	200.7	50	55.4	132	91
Cadmium (Cd)	200.7	5	<5	<5	<5
Calcium (Ca)	200.7	32.6	16400	22700	17600
Chromium (Cr)	200.7	10	<10	<10	<10
Cobalt	200.7	10	43.8	<10	<10
Copper (Cu)	200.7	10	10.6	<10	<10
Iron	200.7	10	17.7	1940	48.6
Lead (Pb)	200.7	50	<50	<50	<50
Magnesium (Mg)	200.7	29	5760	15400	5320
Manganese (Mn)	200.7	1	670	543	2.6
Mercury (Hg)	245.1	0.2	<0.2	<0.2	<0.2
Molybdenum (Mo)	200.7	30	<30	<30	<30
Nickel (Ni)	200.7	5	26.7	10.2	<5
Potassium (K)	200.7	50	2330	4570	2100
Selenium (Se)	270.2	11.1	<50		
		50		<50	<50
Silver (Ag)	200.7	0.4	<0.4	<0.4	<0.4
Sodium (Na)	200.7	50	58400	93200	19500
Thallium	200.7	50	<50	<50	<50
Tin (Sn)	200.7	9.7	<10		
		10		<10	<10
Zinc (Zn)	200.7	10	68.6	78.8	193

[a] All results expressed as µg/L.

TABLE A1-4A. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C	100% APG-EA
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	113.4	55.0	3.7
Bromodichloromethane	8021	0.5	ND	ND	ND
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	41.2	37.0	ND
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	ND
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	62.4	16.0	1.9
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	3.6	0.7	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4A. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
cis-1,2-Dichloroethene	8021	0.5	2.9	1.7	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	72.5	9.5	ND
Tetrachloroethene	8021	0.5	5.7	6.5	ND
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	ND	ND	ND
1,1,2-Trichloroethane	8021	0.5	0.7	ND	ND
Trichloroethene	8021	0.5	98.8	4.1	ND
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4A. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Bis-(2-chloroethoxy) Methane	8270	10.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	10.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	10.0	ND	ND	ND
2-Chloronapthalene	8270	10.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Chrysene	8270	10.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	10.0	ND	ND	ND
Acenaphthylene	8270	10.0	ND	ND	ND
1,2-Dichlorobenzene	8270	10.0	ND	ND	ND
1,3-Dichlorobenzene	8270	10.0	ND	ND	ND
1,4-Dichlorobenzene	8270	10.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	20.0	ND	ND	ND
Diethyl Phthalate	8270	10.0	ND	ND	ND
Dimethyl Phthalate	8270	10.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	10.0	ND	ND	ND
2,4-Dinitrotoluene	8270	10.0	ND	ND	ND
2,6-Dinitrotoluene	8270	10.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	10.0	ND	ND	ND
Fluoranthene	8270	10.0	ND	ND	ND
Fluorene	8270	10.0	ND	ND	ND
Hexachlorobenzene	8270	10.0	ND	ND	ND
Hexachlorobutadiene	8270	10.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	10.0	ND	ND	ND
Hexachloroethane	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4A. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Indeno[1,2,3-cd]pyrene	8270	10.0	ND	ND	ND
Isophorone	8270	10.0	ND	ND	ND
Naphthalene	8270	10.0	ND	ND	ND
Anthracene	8270	10.0	ND	ND	ND
Nitrobenzene	8270	10.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	10.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	10.0	ND	ND	ND
Phenanthrene	8270	10.0	ND	ND	ND
Pyrene	8270	10.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	10.0	ND	ND	ND
Benzo(a)anthracene	8270	10.0	ND	ND	ND
Benzo(a)pyrene	8270	10.0	ND	ND	ND
Benzo(b)fluoranthene	8270	10.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	10.0	ND	ND	ND
Benzo(k)fluoranthene	8270	10.0	ND	ND	ND
Benzidine	8270	10.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	20.0	ND	ND	ND
N-Nitrosodimethylamine	8270	20.0	ND	ND	ND
Acenaphthene	8270	10.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	10.0	ND	ND	ND
4-Chloroaniline	8270	20.0	ND	ND	ND
2-Methylnaphthalene	8270	10.0	ND	ND	ND
2-Nitroaniline	8270	50.0	ND	ND	ND
4-Nitroaniline	8270	20.0	ND	ND	ND
Dibenzofuran	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4A. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Phenol	8270	10.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	10.0	ND	ND	ND
2-Chlorophenol	8270	10.0	ND	ND	ND
2,4-Dichlorophenol	8270	10.0	ND	ND	ND
2,4-Dimethylphenol	8270	10.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	50.0	ND	ND	ND
2,4-Dinitrophenol	8270	50.0	ND	ND	ND
2-Nitrophenol	8270	10.0	ND	ND	ND
4-Nitrophenol	8270	50.0	ND	ND	ND
p-Chloro-m-cresol	8270	20.0	ND	ND	ND
Pentachlorophenol	8270	50.0	ND	ND	ND
p-Cresol	8270	10.0	ND	ND	ND
o-Cresol	8270	10.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4A. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Azinphos-methyl	8140	0.20	ND	ND	ND
Bolstar (Sulprofos)	8140	0.14	ND	ND	ND
Coumaphos	8140	0.40	ND	ND	ND
Demeton, -O, -S	8140	0.24	ND	ND	ND
Diazinon	8140	0.40	ND	ND	ND
Dichlorvos	8140	1.60	ND	ND	ND
Dimethoate	8140	0.52	ND	ND	ND
Disulfoton	8140	0.14	ND	ND	ND
EPN	8140	0.08	ND	ND	ND
Ethoprop	8140	0.40	ND	ND	ND
Fensulfothion	8140	0.16	ND	ND	ND
Fenthion	8140	0.16	ND	ND	ND
Malathion	8140	0.22	ND	ND	ND
Merphos	8140	0.40	ND	ND	ND
Mevinphos	8140	1.00	ND	ND	ND
Naled	8140	1.00	ND	ND	ND
Parathion	8140	0.24	ND	ND	ND
Phorate	8140	0.08	ND	ND	ND
Ronnel	8140	0.14	ND	ND	ND
Sulfotep	8140	0.14	ND	ND	ND
TEPP	8140	1.60	ND	ND	ND
Tetrachlorovinphos	8140	1.60	ND	ND	ND
Tokuthion	8140	0.14	ND	ND	ND
Trichloronate	8140	1.60	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4A. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C	100% APG-EA
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Dursban	8080	0.0044	ND	ND	ND
Herbicides:					
2,4-D	8150	1.5	ND	ND	ND
2,4,5-TP	8150	0.05	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4B. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY CHRONIC HISTOPATHOLOGY GROUNDWATER EXPOSURE AQUARIA DILUTED WITH APG-EA TAP WATER (TEST NO. 4) - GENERAL WATER QUALITY[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Alkalinity ($CaCO_3$)	310.1	1.0	22.6	29.0	30.6
Ammonia Nitrogen (N)	350.3	0.01	0.069	0.047	0.050
Bromide	320.1	0.2	<0.2	<0.2	<0.2
Chloride (Cl)	325.3	1.0	39.0	28.0	28.0
Cyanide (Cn)	335.2	0.002	<0.006	<0.006	<0.006
Fluoride (F)	340.2	0.01	0.621	0.723	0.785
Hardness ($CaCO_3$)	AA	_	62.9	62.0	62.8
pH (electrometric)	150.1	0.01	5.62	6.98	7.12
Nitrate (N)	ISE	0.01	2.50	2.70	2.73
Nitrite (N)	354.1	0.001	<0.002	0.002	0.019
Phosphate (P)	365.3	0.1	0.436	0.279	0.304
Specific Conductance @ 25 °C	120.1	1.0	272	222	214
Sulfate (SO_4)	375.3	1.0	51.2	36.8	38.0
Sulfide (H_2S)	9030	0.002	<0.002	<0.002	<0.002
Total Organic Carbon	415.1	2.0	<2.0	<2.0	<2.0
Total Suspended Solids	160.2	1.0	1.2	2.7	10.6?

[a] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-4B. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Aluminum (Al)	200.7	10	489	148	84.2
Antimony (Sb)	204.2	50	<50	<50	<50
Arsenic (As)	200.7	3.2	<3.2	<3.2	<3.2
Beryllium (Be)	200.7	1	<1	<1	<1
Boron	200.7	50	148	67.9	<50
Cadmium (Cd)	200.7	5	<5	<5	<5
Calcium (Ca)	200.7	32.6	17600	17400	17700
Chromium (Cr)	200.7	10	<10	<10	<10
Cobalt	200.7	10	<10	<10	<10
Copper (Cu)	200.7	10	<10	<10	42.7
Iron	200.7	10	11.1	38.4	26.2
Lead (Pb)	200.7	50	<50	<50	
		14.5			<50
Magnesium (Mg)	200.7	29	5400	5290	5290
Manganese (Mn)	200.7	1	172	34.2	8.6
Mercury (Hg)	245.1	0.2	<0.2	<0.2	<0.2
Molybdenum (Mo)	200.7	30	<30	<30	<30
Nickel (Ni)	200.7	5	8.9	9.7	78.0?
Potassium (K)	200.7	50	2080	2020	2080
Selenium (Se)	270.2	50	<50	<50	
	200.7	50			<50
Silver (Ag)	200.7	0.4	<0.4	<0.4	<0.4
Sodium (Na)	200.7	50	29300	20700	20200
Thallium	200.7	50	<50	<50	<50
Tin (Sn)	200.7	9.7	<10		<100?
		10		<10	
Zinc (Zn)	200.7	10	156	178	181

[a] All results expressed as μg/L.

TABLE A1-4B. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	19.7	5.7	2.9
Bromodichloromethane	8021	0.5	ND	ND	ND
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	7.8	2.4	ND
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	ND
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	10.7	3.0	1.5
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	ND	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4B. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
cis-1,2-Dichloroethene	8021	0.5	ND	ND	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	17.2	3.9	ND
Tetrachloroethene	8021	0.5	ND	ND	ND
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	ND	ND	ND
1,1,2-Trichloroethane	8021	0.5	ND	ND	ND
Trichloroethene	8021	0.5	14.7	2.6	ND
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4B. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Bis-(2-chloroethoxy) Methane	8270	10.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	10.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	10.0	ND	ND	ND
2-Chloronapthalene	8270	10.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Chrysene	8270	10.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	10.0	ND	ND	ND
Acenaphthylene	8270	10.0	ND	ND	ND
1,2-Dichlorobenzene	8270	10.0	ND	ND	ND
1,3-Dichlorobenzene	8270	10.0	ND	ND	ND
1,4-Dichlorobenzene	8270	10.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	20.0	ND	ND	ND
Diethyl Phthalate	8270	10.0	ND	ND	ND
Dimethyl Phthalate	8270	10.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	10.0	ND	ND	ND
2,4-Dinitrotoluene	8270	10.0	ND	ND	ND
2,6-Dinitrotoluene	8270	10.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	10.0	ND	ND	ND
Fluoranthene	8270	10.0	ND	ND	ND
Fluorene	8270	10.0	ND	ND	ND
Hexachlorobenzene	8270	10.0	ND	ND	ND
Hexachlorobutadiene	8270	10.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	10.0	ND	ND	ND
Hexachloroethane	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4B. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Indeno[1,2,3-cd]pyrene	8270	10.0	ND	ND	ND
Isophorone	8270	10.0	ND	ND	ND
Naphthalene	8270	10.0	ND	ND	ND
Anthracene	8270	10.0	ND	ND	ND
Nitrobenzene	8270	10.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	10.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	10.0	ND	ND	ND
Phenanthrene	8270	10.0	ND	ND	ND
Pyrene	8270	10.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	10.0	ND	ND	ND
Benzo(a)anthracene	8270	10.0	ND	ND	ND
Benzo(a)pyrene	8270	10.0	ND	ND	ND
Benzo(b)fluoranthene	8270	10.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	10.0	ND	ND	ND
Benzo(k)fluoranthene	8270	10.0	ND	ND	ND
Benzidine	8270	10.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	20.0	ND	ND	ND
N-Nitrosodimethylamine	8270	20.0	ND	ND	ND
Acenaphthene	8270	10.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	10.0	ND	ND	ND
4-Chloroaniline	8270	20.0	ND	ND	ND
2-Methylnaphthalene	8270	10.0	ND	ND	ND
2-Nitroaniline	8270	50.0	ND	ND	ND
4-Nitroaniline	8270	20.0	ND	ND	ND
Dibenzofuran	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4B. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Phenol	8270	10.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	10.0	ND	ND	ND
2-Chlorophenol	8270	10.0	ND	ND	ND
2,4-Dichlorophenol	8270	10.0	ND	ND	ND
2,4-Dimethylphenol	8270	10.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	50.0	ND	ND	ND
2,4-Dinitrophenol	8270	50.0	ND	ND	ND
2-Nitrophenol	8270	10.0	ND	ND	ND
4-Nitrophenol	8270	50.0	ND	ND	ND
p-Chloro-m-cresol	8270	20.0	ND	ND	ND
Pentachlorophenol	8270	50.0	ND	ND	ND
p-Cresol	8270	10.0	ND	ND	ND
o-Cresol	8270	10.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4B. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Azinphos-methyl	8140	0.20	ND	ND	ND
Bolstar (Sulprofos)	8140	0.14	ND	ND	ND
Coumaphos	8140	0.40	ND	ND	ND
Demeton, -O, -S	8140	0.24	ND	ND	ND
Diazinon	8140	0.40	ND	ND	ND
Dichlorvos	8140	1.60	ND	ND	ND
Dimethoate	8140	0.52	ND	ND	ND
Disulfoton	8140	0.14	ND	ND	ND
EPN	8140	0.08	ND	ND	ND
Ethoprop	8140	0.40	ND	ND	ND
Fensulfothion	8140	0.16	ND	ND	ND
Fenthion	8140	0.16	ND	ND	ND
Malathion	8140	0.22	ND	ND	ND
Merphos	8140	0.40	ND	ND	ND
Mevinphos	8140	1.00	ND	ND	ND
Naled	8140	1.00	ND	ND	ND
Parathion	8140	0.24	ND	ND	ND
Phorate	8140	0.08	ND	ND	ND
Ronnel	8140	0.14	ND	ND	ND
Sulfotep	8140	0.14	ND	ND	ND
TEPP	8140	1.60	ND	ND	ND
Tetrachlorovinphos	8140	1.60	ND	ND	ND
Tokuthion	8140	0.14	ND	ND	ND
Trichloronate	8140	1.60	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4B. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Dursban	8080	0.0044	ND	ND	ND
Herbicides:					
2,4-D	8150	1.5	ND	ND	ND
2,4,5-TP	8150	0.05	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4C. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY CHRONIC HISTOPATHOLOGY GROUNDWATER EXPOSURE AQUARIA FORMERLY DILUTED WITH WEST BRANCH OF CANAL CREEK WATER (TEST NO. 4)[a] - GENERAL WATER QUALITY[b]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Alkalinity ($CaCO_3$)	310.1	1.0	22.4	29.0	30.4
Ammonia Nitrogen (N)	350.3	0.01	0.080	0.044	0.060
Bromide	320.1	0.2	<0.2	<0.2	<0.2
Chloride (Cl)	325.3	1.0	39	28	28
Cyanide (Cn)	335.2	0.002	<0.006	<0.006	<0.006
Fluoride (F)	340.2	0.01	0.614	0.738	0.779
Hardness ($CaCO_3$)	AA	_	60.5	60.7	61.7
pH (electrometric)	150.1	0.01	6.40	6.94	6.55
Nitrate (N)	ISE	0.01	2.48	2.72	2.75
Nitrite (N)	354.1	0.001	<0.002	<0.002	<0.002
Phosphate (P)	365.3	0.1	0.206	0.247	0.279
Specific Conductance @ 25 °C	120.1	1.0	271	227	226
Sulfate (SO_4)	375.3	1.0	53.2	37.6	35.2
Sulfide (H_2S)	9030	0.002	<0.002	<0.002	<0.002
Total Organic Carbon	415.1	2.0	<2.0	<2.0	2.2
Total Suspended Solids	160.2	1.0	<1.0	<1.0	1.1

[a] The aquaria in this series were diluted with West Branch of Canal Creek water from the beginning of the study to February 5, 1995. APG-EA dechlorinated tap water was used from February 5, 1995 through the end of the study. See Section 4.6 for further explanation.

[b] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-4C. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Aluminum (Al)	200.7	10	482	92.4	125
Antimony (Sb)	204.2	50	<50	<50	<50
Arsenic (As)	200.7	3.2	<3.2	<3.2	<3.2
Beryllium (Be)	200.7	1	<1	<1	<1
Boron	200.7	50	68.5	<50	79
Cadmium (Cd)	200.7	5	<5	<5	<5
Calcium (Ca)	200.7	32.6	17000	17200	17600
Chromium (Cr)	200.7	10	<10	<10	<10
Cobalt	200.7	10	14.3	<10	<10
Copper (Cu)	200.7	10	<10	<10	<10
Iron	200.7	10	12.9	21.6	41.3
Lead (Pb)	200.7	50	<50	<50	<50
Magnesium (Mg)	200.7	29	5130	5070	5050
Manganese (Mn)	200.7	1	168	35.4	14.5
Mercury (Hg)	245.1	0.2	<0.2	<0.2	<0.2
Molybdenum (Mo)	200.7	30	<30	<30	<30
Nickel (Ni)	200.7	5	11.1	5.2	6.5
Potassium (K)	200.7	50	2110	1890	2010
Selenium (Se)	270.2	50	<50	<50	<50
Silver (Ag)	200.7	0.4	<0.4	<0.4	<0.4
Sodium (Na)	200.7	50	28700	20600	20100
Thallium	200.7	50	<50	<50	<50
Tin (Sn)	200.7	10	<10	<10	<10
Zinc (Zn)	200.7	10	149	164	191

[a] All results expressed as μg/L.

TABLE A1-4C. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	22.5	6.8	3.5
Bromodichloromethane	8021	0.5	ND	ND	ND
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	8.6	3.6	ND
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	ND
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	12.5	3.8	2.0
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	ND	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4C. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
cis-1,2-Dichloroethene	8021	0.5	ND	ND	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	18.2	4.4	0.8
Tetrachloroethene	8021	0.5	0.7	ND	ND
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	ND	ND	ND
1,1,2-Trichloroethane	8021	0.5	ND	ND	ND
Trichloroethene	8021	0.5	16.7	4.0	ND
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4C. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Bis-(2-chloroethoxy) Methane	8270	10.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	10.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	10.0	ND	ND	ND
2-Chloronapthalene	8270	10.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Chrysene	8270	10.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	10.0	ND	ND	ND
Acenaphthylene	8270	10.0	ND	ND	ND
1,2-Dichlorobenzene	8270	10.0	ND	ND	ND
1,3-Dichlorobenzene	8270	10.0	ND	ND	ND
1,4-Dichlorobenzene	8270	10.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	20.0	ND	ND	ND
Diethyl Phthalate	8270	10.0	ND	ND	ND
Dimethyl Phthalate	8270	10.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	10.0	ND	ND	ND
2,4-Dinitrotoluene	8270	10.0	ND	ND	ND
2,6-Dinitrotoluene	8270	10.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	10.0	ND	ND	ND
Fluoranthene	8270	10.0	ND	ND	ND
Fluorene	8270	10.0	ND	ND	ND
Hexachlorobenzene	8270	10.0	ND	ND	ND
Hexachlorobutadiene	8270	10.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	10.0	ND	ND	ND
Hexachloroethane	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4C. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Indeno[1,2,3-cd]pyrene	8270	10.0	ND	ND	ND
Isophorone	8270	10.0	ND	ND	ND
Naphthalene	8270	10.0	ND	ND	ND
Anthracene	8270	10.0	ND	ND	ND
Nitrobenzene	8270	10.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	10.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	10.0	ND	ND	ND
Phenanthrene	8270	10.0	ND	ND	ND
Pyrene	8270	10.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	10.0	ND	ND	ND
Benzo(a)anthracene	8270	10.0	ND	ND	ND
Benzo(a)pyrene	8270	10.0	ND	ND	ND
Benzo(b)fluoranthene	8270	10.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	10.0	ND	ND	ND
Benzo(k)fluoranthene	8270	10.0	ND	ND	ND
Benzidine	8270	10.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	20.0	ND	ND	ND
N-Nitrosodimethylamine	8270	20.0	ND	ND	ND
Acenaphthene	8270	10.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	10.0	ND	ND	ND
4-Chloroaniline	8270	20.0	ND	ND	ND
2-Methylnaphthalene	8270	10.0	ND	ND	ND
2-Nitroaniline	8270	50.0	ND	ND	ND
4-Nitroaniline	8270	20.0	ND	ND	ND
Dibenzofuran	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4C. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Phenol	8270	10.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	10.0	ND	ND	ND
2-Chlorophenol	8270	10.0	ND	ND	ND
2,4-Dichlorophenol	8270	10.0	ND	ND	ND
2,4-Dimethylphenol	8270	10.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	50.0	ND	ND	ND
2,4-Dinitrophenol	8270	50.0	ND	ND	ND
2-Nitrophenol	8270	10.0	ND	ND	ND
4-Nitrophenol	8270	50.0	ND	ND	ND
p-Chloro-m-cresol	8270	20.0	ND	ND	ND
Pentachlorophenol	8270	50.0	ND	ND	ND
p-Cresol	8270	10.0	ND	ND	ND
o-Cresol	8270	10.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4C. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Azinphos-methyl	8140	0.20	ND	ND	ND
Bolstar (Sulprofos)	8140	0.14	ND	ND	ND
Coumaphos	8140	0.40	ND	ND	ND
Demeton, -O, -S	8140	0.24	ND	ND	ND
Diazinon	8140	0.40	ND	ND	ND
Dichlorvos	8140	1.60	ND	ND	ND
Dimethoate	8140	0.52	ND	ND	ND
Disulfoton	8140	0.14	ND	ND	ND
EPN	8140	0.08	ND	ND	ND
Ethoprop	8140	0.40	ND	ND	ND
Fensulfothion	8140	0.16	ND	ND	ND
Fenthion	8140	0.16	ND	ND	ND
Malathion	8140	0.22	ND	ND	ND
Merphos	8140	0.40	ND	ND	ND
Mevinphos	8140	1.00	ND	ND	ND
Naled	8140	1.00	ND	ND	ND
Parathion	8140	0.24	ND	ND	ND
Phorate	8140	0.08	ND	ND	ND
Ronnel	8140	0.14	ND	ND	ND
Sulfotep	8140	0.14	ND	ND	ND
TEPP	8140	1.60	ND	ND	ND
Tetrachlorovinphos	8140	1.60	ND	ND	ND
Tokuthion	8140	0.14	ND	ND	ND
Trichloronate	8140	1.60	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-4C. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Dursban	8080	0.0044	ND	ND	ND
Herbicides:					
2,4-D	8150	1.5	ND	ND	ND
2,4,5-TP	8150	0.05	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5A. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY GROUNDWATER (WELL NO. CC-27B), WEST BRANCH OF CANAL CREEK SURFACE WATER, AND APG-EA TAP WATER (TEST NO. 5) - GENERAL WATER QUALITY[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Alkalinity ($CaCO_3$)	310.1	1.0	4.0	92	80
Ammonia Nitrogen (N)	350.3	0.01	0.049	0.078	0.067
Bromide	320.1	0.2	<0.2	<0.2	<0.2
Chloride (Cl)	325.3	1.0	83.5	882	26.4
Cyanide (Cn)	335.2	0.006	<0.006	<0.006	<0.006
Fluoride (F)	340.2	0.01	0.260	0.107	0.797
Hardness ($CaCO_3$)	AA	_	66.4	282	52.9
pH (electrometric)	150.1	0.01	4.30	7.72	7.00
Nitrate (N)	ISE	0.01	2.87	1.28	2.32
Nitrite (N)	354.1	0.001	<0.002	0.025	0.008
Phosphate (P)	365.3	0.1	1.11	0.122	1.08
Specific Conductance @ 25 °C	120.1	1.0	439	2005	218
Sulfate (SO_4)	375.3	1.0	119	139	25
Sulfide (H_2S)	9030	0.002	<0.002	<0.002	<0.002
Total Organic Carbon	415.1	2.0	<2.0	3.8	<2.0
Total Suspended Solids	160.2	1.0	3.5	20.1	<1.0

[a] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-5A. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Aluminum (Al)	200.7	10	1850	759	102
Antimony (Sb)	204.2	50	<50	<50	<50
Arsenic (As)	206.2	5	<5	<5	<5
Beryllium (Be)	200.7	0.5	1.8	<0.5	<0.5
Boron	200.7	50	296	402	214
Cadmium (Cd)	200.7	5	<5	<5	<5
Calcium (Ca)	200.7	32.6	17600	31300	14300
Chromium (Cr)	200.7	10	<10	<10	<10
Cobalt	200.7	10	46.1	<10	<10
Copper (Cu)	200.7	10	12.3	<10	<10
Iron	200.7	10	<10	1140	<10
Lead (Pb)	200.7	50	<50	<50	<50
Magnesium (Mg)	200.7	29	6390	58300	4900
Manganese (Mn)	200.7	5	693	119	<5
Mercury (Hg)	245.1	0.1	<0.1	<0.1	<0.1
Molybdenum (Mo)	200.7	30	<30	34.7	<30
Nickel (Ni)	200.7	5	24.8	<5	<5
Potassium (K)	200.7	50	2750	21700	2090
Selenium (Se)	270.2	50	<50	<50	<50
Silver (Ag)	272.2	0.5	<0.5	<0.5	<0.5
Sodium (Na)	200.7	50	62600	452000	23600
Thallium	200.7	50	<50	<50	<50
Tin (Sn)	200.7	10	<10	<10	<10
Zinc (Zn)	200.7	10	76.2	119	253

[a] All results expressed as μg/L.

TABLE A1-5A. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C	100% APG-EA
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	4.6	ND	ND
Bromodichloromethane	8021	0.5	ND	ND	ND
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	43.9	1.9	ND
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	ND
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	63.4	ND	9.9
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	ND	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5A. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
cis-1,2-Dichloroethene	8021	0.5	3.3	ND	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	75.9	ND	ND
Tetrachloroethene	8021	0.5	6.7	ND	ND
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	4.6	ND	ND
1,1,2-Trichloroethane	8021	0.5	0.7	ND	ND
Trichloroethene	8021	0.5	102.0	ND	ND
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5A. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Bis-(2-chloroethoxy) Methane	8270	10.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	10.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	10.0	ND	ND	ND
2-Chloronapthalene	8270	10.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Chrysene	8270	10.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	10.0	ND	ND	ND
Acenaphthylene	8270	10.0	ND	ND	ND
1,2-Dichlorobenzene	8270	10.0	ND	ND	ND
1,3-Dichlorobenzene	8270	10.0	ND	ND	ND
1,4-Dichlorobenzene	8270	10.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	20.0	ND	ND	ND
Diethyl Phthalate	8270	10.0	ND	ND	ND
Dimethyl Phthalate	8270	10.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	10.0	ND	ND	ND
2,4-Dinitrotoluene	8270	10.0	ND	ND	ND
2,6-Dinitrotoluene	8270	10.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	10.0	ND	ND	ND
Fluoranthene	8270	10.0	ND	ND	ND
Fluorene	8270	10.0	ND	ND	ND
Hexachlorobenzene	8270	10.0	ND	ND	ND
Hexachlorobutadiene	8270	10.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	10.0	ND	ND	ND
Hexachloroethane	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5A. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Indeno[1,2,3-cd]pyrene	8270	10.0	ND	ND	ND
Isophorone	8270	10.0	ND	ND	ND
Naphthalene	8270	10.0	ND	ND	ND
Anthracene	8270	10.0	ND	ND	ND
Nitrobenzene	8270	10.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	10.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	10.0	ND	ND	ND
Phenanthrene	8270	10.0	ND	ND	ND
Pyrene	8270	10.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	10.0	ND	ND	ND
Benzo(a)anthracene	8270	10.0	ND	ND	ND
Benzo(a)pyrene	8270	10.0	ND	ND	ND
Benzo(b)fluoranthene	8270	10.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	10.0	ND	ND	ND
Benzo(k)fluoranthene	8270	10.0	ND	ND	ND
Benzidine	8270	10.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	20.0	ND	ND	ND
N-Nitrosodimethylamine	8270	20.0	ND	ND	ND
Acenaphthene	8270	10.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	10.0	ND	ND	ND
4-Chloroaniline	8270	20.0	ND	ND	ND
2-Methylnaphthalene	8270	10.0	ND	ND	ND
2-Nitroaniline	8270	50.0	ND	ND	ND
4-Nitroaniline	8270	20.0	ND	ND	ND
Dibenzofuran	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5A. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Phenol	8270	10.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	10.0	ND	ND	ND
2-Chlorophenol	8270	10.0	ND	ND	ND
2,4-Dichlorophenol	8270	10.0	ND	ND	ND
2,4-Dimethylphenol	8270	10.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	50.0	ND	ND	ND
2,4-Dinitrophenol	8270	50.0	ND	ND	ND
2-Nitrophenol	8270	10.0	ND	ND	ND
4-Nitrophenol	8270	50.0	ND	ND	ND
p-Chloro-m-cresol	8270	20.0	ND	ND	ND
Pentachlorophenol	8270	50.0	ND	ND	ND
p-Cresol	8270	10.0	ND	ND	ND
o-Cresol	8270	10.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5A. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C.	100% APG-EA
Azinphos-methyl	8140	0.20	ND	ND	ND
Bolstar (Sulprofos)	8140	0.14	ND	ND	ND
Coumaphos	8140	0.40	ND	ND	ND
Demeton, -O, -S	8140	0.24	ND	ND	ND
Diazinon	8140	0.40	ND	ND	ND
Dichlorvos	8140	1.60	ND	ND	ND
Dimethoate	8140	0.52	ND	ND	ND
Disulfoton	8140	0.14	ND	ND	ND
EPN	8140	0.08	ND	ND	ND
Ethoprop	8140	0.40	ND	ND	ND
Fensulfothion	8140	0.16	ND	ND	ND
Fenthion	8140	0.16	ND	ND	ND
Malathion	8140	0.22	ND	ND	ND
Merphos	8140	0.40	ND	ND	ND
Mevinphos	8140	1.00	ND	ND	ND
Naled	8140	1.00	ND	ND	ND
Parathion	8140	0.24	ND	ND	ND
Phorate	8140	0.08	ND	ND	ND
Ronnel	8140	0.14	ND	ND	ND
Sulfotep	8140	0.14	ND	ND	ND
TEPP	8140	1.60	ND	ND	ND
Tetrachlorovinphos	8140	1.60	ND	ND	ND
Tokuthion	8140	0.14	ND	ND	ND
Trichloronate	8140	1.60	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5A. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	100% G.W.	100% W.B.C.C	100% APG-EA
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Dursban	8080	0.0044	ND	ND	ND
Herbicides:					
2,4-D	8150	1.5	ND	ND	ND
2,4,5-TP	8150	0.05	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5B. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY CHRONIC HISTOPATHOLOGY GROUNDWATER EXPOSURE AQUARIA DILUTED WITH APG-EA TAP WATER (TEST NO. 5) - GENERAL WATER QUALITY[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Alkalinity ($CaCO_3$)	310.1	1.0	60	96	80
Ammonia Nitrogen (N)	350.3	0.01	0.092	0.065	0.067
Bromide	320.1	0.2	<0.2	<0.2	<0.2
Chloride (Cl)	325.3	1.0	39.0	29.0	27.2
Cyanide (Cn)	335.2	0.006	<0.006	<0.006	<0.006
Fluoride (F)	340.2	0.01	0.585	0.725	0.757
Hardness ($CaCO_3$)	AA	_	58.1	54.2	55.8
pH (electrometric)	150.1	0.01	6.68	7.25	7.44
Nitrate (N)	ISE	0.01	2.14	2.23	2.23
Nitrite (N)	354.1	0.001	<0.002	0.002	0.008
Phosphate (P)	365.3	0.1	1.05	0.408	0.424
Specific Conductance @ 25 °C	120.1	1.0	272	216	216
Sulfate (SO_4)	375.3	1.0	61.8	35.2	31.2
Sulfide (H_2S)	9030	0.002	<0.002	<0.002	<0.002
Total Organic Carbon	415.1	2.0	<2.0	<2.0	<2.0
Total Suspended Solids	160.2	1.0	<1.0	<1.0	1.5

[a] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-5B. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Aluminum (Al)	200.7	10	630	218	102
Antimony (Sb)	204.2	50	<50	<50	<50
Arsenic (As)	206.2	5	<5	<5	<5
Beryllium (Be)	200.7	0.5	1	<0.5	<0.5
Boron	200.7	50	242	229	171
Cadmium (Cd)	200.7	5	<5	<5	<5
Calcium (Ca)	200.7	32.6	15400	14500	15000
Chromium (Cr)	200.7	10	<10	<10	<10
Cobalt	200.7	10	11	<10	<10
Copper (Cu)	200.7	10	<10	<10	<10
Iron	200.7	10	<10	<10	<10
Lead (Pb)	200.7	50	<50	<50	<50
Magnesium (Mg)	200.7	29	5610	5120	5220
Manganese (Mn)	200.7	0.97	167		5.6
		5		29.5	
Mercury (Hg)	245.1	0.1	<0.1	<0.1	<0.1
Molybdenum (Mo)	200.7	30	<30	<30	<30
Nickel (Ni)	200.7	5	7.2	5.5	5.7
Potassium (K)	200.7	50	2460	2070	2240
Selenium (Se)	270.2	50	<50	<50	<50
Silver (Ag)	272.2	0.5	<0.5	<0.5	<0.5
Sodium (Na)	200.7	50	34300	25100	25100
Thallium	200.7	50	<50	<50	<50
Tin (Sn)	200.7	10	<10		<10
		0.97		<10	
Zinc (Zn)	200.7	5	190		248
		1.5		224	

[a] All results expressed as μg/L.

TABLE A1-5B. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	ND	ND	ND
Bromodichloromethane	8021	0.5	ND	ND	ND
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	8.3	2.6	ND
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	ND
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	17.7	11.4	9.3
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	ND	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5B. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
cis-1,2-Dichloroethene	8021	0.5	ND	ND	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	18.4	4.3	0.8
Tetrachloroethene	8021	0.5	ND	ND	ND
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	ND	ND	ND
1,1,2-Trichloroethane	8021	0.5	ND	ND	ND
Trichloroethene	8021	0.5	17.3	3.2	ND
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5B. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Bis-(2-chloroethoxy) Methane	8270	10.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	10.0	ND	ND	ND
4-Bromophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	10.0	ND	ND	ND
2-Chloronapthalene	8270	10.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Chrysene	8270	10.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	10.0	ND	ND	ND
Acenaphthylene	8270	10.0	ND	ND	ND
1,2-Dichlorobenzene	8270	10.0	ND	ND	ND
1,3-Dichlorobenzene	8270	10.0	ND	ND	ND
1,4-Dichlorobenzene	8270	10.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	20.0	ND	ND	ND
Diethyl Phthalate	8270	10.0	ND	ND	ND
Dimethyl Phthalate	8270	10.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	10.0	ND	ND	ND
2,4-Dinitrotoluene	8270	10.0	ND	ND	ND
2,6-Dinitrotoluene	8270	10.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	10.0	ND	ND	ND
Fluoranthene	8270	10.0	ND	ND	ND
Fluorene	8270	10.0	ND	ND	ND
Hexachlorobenzene	8270	10.0	ND	ND	ND
Hexachlorobutadiene	8270	10.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	10.0	ND	ND	ND
Hexachloroethane	8270	10.0	ND	ND	ND

[a] All results expressed as µg/L.

TABLE A1-5B. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Indeno[1,2,3-cd]pyrene	8270	10.0	ND	ND	ND
Isophorone	8270	10.0	ND	ND	ND
Naphthalene	8270	10.0	ND	ND	ND
Anthracene	8270	10.0	ND	ND	ND
Nitrobenzene	8270	10.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	10.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	10.0	ND	ND	ND
Phenanthrene	8270	10.0	ND	ND	ND
Pyrene	8270	10.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	10.0	ND	ND	ND
Benzo(a)anthracene	8270	10.0	ND	ND	ND
Benzo(a)pyrene	8270	10.0	ND	ND	ND
Benzo(b)fluoranthene	8270	10.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	10.0	ND	ND	ND
Benzo(k)fluoranthene	8270	10.0	ND	ND	ND
Benzidine	8270	10.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	20.0	ND	ND	ND
N-Nitrosodimethylamine	8270	20.0	ND	ND	ND
Acenaphthene	8270	10.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	10.0	ND	ND	ND
4-Chloroaniline	8270	20.0	ND	ND	ND
2-Methylnaphthalene	8270	10.0	ND	ND	ND
2-Nitroaniline	8270	50.0	ND	ND	ND
4-Nitroaniline	8270	20.0	ND	ND	ND
Dibenzofuran	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5B. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Phenol	8270	10.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	10.0	ND	ND	ND
2-Chlorophenol	8270	10.0	ND	ND	ND
2,4-Dichlorophenol	8270	10.0	ND	ND	ND
2,4-Dimethylphenol	8270	10.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	50.0	ND	ND	ND
2,4-Dinitrophenol	8270	50.0	ND	ND	ND
2-Nitrophenol	8270	10.0	ND	ND	ND
4-Nitrophenol	8270	50.0	ND	ND	ND
p-Chloro-m-cresol	8270	20.0	ND	ND	ND
Pentachlorophenol	8270	50.0	ND	ND	ND
p-Cresol	8270	10.0	ND	ND	ND
o-Cresol	8270	10.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5B. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Azinphos-methyl	8140	0.20	ND	ND	ND
Bolstar (Sulprofos)	8140	0.14	ND	ND	ND
Coumaphos	8140	0.40	ND	ND	ND
Demeton, -O, -S	8140	0.24	ND	ND	ND
Diazinon	8140	0.40	ND	ND	ND
Dichlorvos	8140	1.60	ND	ND	ND
Dimethoate	8140	0.52	ND	ND	ND
Disulfoton	8140	0.14	ND	ND	ND
EPN	8140	0.08	ND	ND	ND
Ethoprop	8140	0.40	ND	ND	ND
Fensulfothion	8140	0.16	ND	ND	ND
Fenthion	8140	0.16	ND	ND	ND
Malathion	8140	0.22	ND	ND	ND
Merphos	8140	0.40	ND	ND	ND
Mevinphos	8140	1.00	ND	ND	ND
Naled	8140	1.00	ND	ND	ND
Parathion	8140	0.24	ND	ND	ND
Phorate	8140	0.08	ND	ND	ND
Ronnel	8140	0.14	ND	ND	ND
Sulfotep	8140	0.14	ND	ND	ND
TEPP	8140	1.60	ND	ND	ND
Tetrachlorovinphos	8140	1.60	ND	ND	ND
Tokuthion	8140	0.14	ND	ND	ND
Trichloronate	8140	1.60	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5B. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Dursban	8080	0.0044	ND	ND	ND
Herbicides:					
2,4-D	8150	1.5	ND	ND	ND
2,4,5-TP	8150	0.05	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5C. COMPREHENSIVE CHEMICAL ANALYSIS OF THE WEST BRANCH OF CANAL CREEK STUDY CHRONIC HISTOPATHOLOGY GROUNDWATER EXPOSURE AQUARIA FROMERLY DILUTED WITH WEST BRANCH CANAL OF CREEK WATER (TEST NO. 5)[a] - GENERAL WATER QUALITY[b]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Alkalinity ($CaCO_3$)	310.1	1.0	64	76	84
Ammonia Nitrogen (N)	350.3	0.01	0.118	0.101	0.097
Bromide	320.1	0.2	<0.2	<0.2	<0.2
Chloride (Cl)	325.3	1.0	43.5	29.0	26.0
Cyanide (Cn)	335.2	0.006	<0.006	<0.006	<0.006
Fluoride (F)	340.2	0.01	0.584	0.748	0.732
Hardness ($CaCO_3$)	AA	_	57.3	55.1	55.4
pH (electrometric)	150.1	0.01	6.72	7.24	7.45
Nitrate (N)	ISE	0.01	2.55	2.21	2.34
Nitrite (N)	354.1	0.001	0.002	0.004	0.007
Phosphate (P)	365.3	0.1	0.628	0.367	0.799
Specific Conductance @ 25 °C	120.1	1.0	274	233	214
Sulfate (SO_4)	375.3	1.0	56.4	35.8	12
Sulfide (H_2S)	9030	0.002	<0.002	<0.002	<0.002
Total Organic Carbon	415.1	2.0	<2.0	<2.0	<2.0
Total Suspended Solids	160.2	1.0	1.5	<1.0	2.5

[a] The aquaria in this series were diluted with West Branch of Canal Creek water from the beginning of the study to February 5, 1995. APG-EA dechlorinated tap water was used from February 5, 1995 through the end of the study. See Section 4.6 for further explanation.

[b] All results expressed as mg/L except for specific conductance and pH which are expressed as μmhos/cm and standard units, respectively.

TABLE A1-5C. (CONTINUED) - METALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Aluminum (Al)	200.7	10	574	247	140
Antimony (Sb)	204.2	50	<50	<50	<50
Arsenic (As)	206.2	5	<5	<5	<5
Beryllium (Be)	200.7	0.5	0.9	0.7	0.7
Boron	200.7	50	269	441	184
Cadmium (Cd)	200.7	5	<5	<5	<5
Calcium (Ca)	200.7	32.6	15200	14600	14700
Chromium (Cr)	200.7	10	<10	<10	<10
Cobalt	200.7	10	10.3	<10	<10
Copper (Cu)	200.7	10	<10	<10	<10
Iron	200.7	10	<10	<10	<10
Lead (Pb)	200.7	50	<50	<50	<50
Magnesium (Mg)	200.7	29	5510	5320	5320
Manganese (Mn)	200.7	1	162		
		5		23.5	<5
Mercury (Hg)	245.1	0.1	<0.1	<0.1	<0.1
Molybdenum (Mo)	200.7	30	<30	<30	<30
Nickel (Ni)	200.7	5	8.4	<5	<5
Potassium (K)	200.7	50	2450	2460	2400
Selenium (Se)	270.2	50	<50	<50	<50
Silver (Ag)	272.2	0.5	<0.5	<0.5	
	270.2				<0.5
Sodium (Na)	200.7	50	33100	26200	24800
Thallium	200.7	50	<50	<50	<50
Tin (Sn)	200.7	10	<10	<10	<10
Zinc (Zn)	200.7	10	177	207	210

[a] All results expressed as μg/L.

TABLE A1-5C. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Benzene	8021	0.5	ND	ND	ND
Bromobenzene	8021	0.5	ND	ND	ND
Bromochloromethane	8021	0.5	ND	ND	ND
Bromodichloromethane	8021	0.5	ND	ND	ND
Bromoform	8021	0.5	ND	ND	ND
Bromomethane	8021	0.5	ND	ND	ND
n-Butylbenzene	8021	0.5	ND	ND	ND
s-Butylbenzene	8021	0.5	ND	ND	ND
t-Butylbenzene	8021	0.5	ND	ND	ND
Carbon Tetrachloride	8021	0.5	8.8	4.2	ND
Chlorobenzene	8021	0.5	ND	ND	ND
Chlorodibromomethane	8021	0.5	ND	ND	ND
Chloroethane	8021	0.5	ND	ND	ND
Chloroform	8021	0.5	19.8	13.3	10.1
Chloromethane	8021	0.5	ND	ND	ND
2-Chlorotoluene	8021	0.5	ND	ND	ND
4-Chlorotoluene	8021	0.5	ND	ND	ND
1,2-Dibromo-3-chloropropane	8021	0.5	ND	ND	ND
1,2-Dibromoethane	8021	0.5	ND	ND	ND
Dibromomethane	8021	0.5	ND	ND	ND
1,2-Dichlorobenzene	8021	0.5	ND	ND	ND
1,3-Dichlorobenzene	8021	0.5	ND	ND	ND
1,4-Dichlorobenzene	8021	0.5	ND	ND	ND
Dichlorodifluoromethane	8021	1.0	ND	ND	ND
1,1-Dichloroethane	8021	0.5	ND	ND	ND
1,2-Dichloroethane	8021	0.5	ND	ND	ND
1,1-Dichloroethene	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5C. (CONTINUED) - PRIORITY POLLUTANT VOLATILE ORGANICS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
cis-1,2-Dichloroethene	8021	0.5	ND	ND	ND
1,1-Dichloropropene	8021	0.5	ND	ND	ND
cis-1,3-Dichloropropene	8021	0.5	ND	ND	ND
trans-1,3-Dichloropropene	8021	0.5	ND	ND	ND
Ethylbenzene	8021	0.5	ND	ND	ND
Hexachlorobutadiene	8021	0.5	ND	ND	ND
Isopropylbenzene	8021	0.5	ND	ND	ND
p-Isopropyltoluene	8021	0.5	ND	ND	ND
Methylene chloride	8021	0.5	ND	ND	ND
Naphthalene	8021	0.5	ND	ND	ND
n-Propylbenzene	8021	0.5	ND	ND	ND
Styrene	8021	0.5	ND	ND	ND
1,1,1,2-Tetrachloroethane	8021	0.5	ND	ND	ND
1,1,2,2-Tetrachloroethane	8021	0.5	19.3	5.5	ND
Tetrachloroethene	8021	0.5	ND	ND	ND
Toluene	8021	0.5	ND	ND	ND
1,2,3-Trichlorobenzene	8021	0.5	ND	ND	ND
1,2,4-Trichlorobenzene	8021	0.5	ND	ND	ND
1,1,1-Trichloroethane	8021	0.5	0.7	ND	ND
1,1,2-Trichloroethane	8021	0.5	ND	ND	ND
Trichloroethene	8021	0.5	19.7	4.7	ND
Trichlorofluoromethane	8021	0.5	ND	ND	ND
1,2,3-Trichloropropane	8021	0.5	ND	ND	ND
1,2,4-Trimethylbenzene	8021	0.5	ND	ND	ND
1,3,5-Trimethylbenzene	8021	0.5	ND	ND	ND
Vinyl Chloride	8021	0.5	ND	ND	ND
o,m,p-Xylenes	8021	0.5	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5C. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Bis-(2-chloroethoxy) Methane	8270	10.0	ND	ND	ND
Bis-(2-chloroethyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-chloroisopropyl) Ether	8270	10.0	ND	ND	ND
Bis-(2-ethylhexyl) Phthalate	8270	10.0	ND	20.4[b]	ND
4-Bromophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Butyl Benzyl Phthalate	8270	10.0	ND	ND	ND
2-Chloronapthalene	8270	10.0	ND	ND	ND
4-Chlorophenyl Phenyl Ether	8270	10.0	ND	ND	ND
Chrysene	8270	10.0	ND	ND	ND
Dibenzo (a,h) Anthracene	8270	10.0	ND	ND	ND
Acenaphthylene	8270	10.0	ND	ND	ND
1,2-Dichlorobenzene	8270	10.0	ND	ND	ND
1,3-Dichlorobenzene	8270	10.0	ND	ND	ND
1,4-Dichlorobenzene	8270	10.0	ND	ND	ND
3,3'-Dichlorobenzidine	8270	20.0	ND	ND	ND
Diethyl Phthalate	8270	10.0	ND	ND	ND
Dimethyl Phthalate	8270	10.0	ND	ND	ND
Di-n-Butyl Phthalate	8270	10.0	ND	ND	ND
2,4-Dinitrotoluene	8270	10.0	ND	ND	ND
2,6-Dinitrotoluene	8270	10.0	ND	ND	ND
Di-n-Octyl Phthalate	8270	10.0	ND	ND	ND
Fluoranthene	8270	10.0	ND	ND	ND
Fluorene	8270	10.0	ND	ND	ND
Hexachlorobenzene	8270	10.0	ND	ND	ND
Hexachlorobutadiene	8270	10.0	ND	ND	ND
Hexachlorocyclopentadiene	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.
[b] Value appears to be spurious; compound not reported for any other data sets.

TABLE A1-5C. (CONTINUED) - PRIORITY POLLUTANT BASE NEUTRALS CON'T[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Hexachloroethane	8270	10.0	ND	ND	ND
Indeno[1,2,3-cd]pyrene	8270	10.0	ND	ND	ND
Isophorone	8270	10.0	ND	ND	ND
Naphthalene	8270	10.0	ND	ND	ND
Anthracene	8270	10.0	ND	ND	ND
Nitrobenzene	8270	10.0	ND	ND	ND
N-Nitroso-di-n-propylamine	8270	10.0	ND	ND	ND
N-Nitrosodiphenylamine	8270	10.0	ND	ND	ND
Phenanthrene	8270	10.0	ND	ND	ND
Pyrene	8270	10.0	ND	ND	ND
1,2,4-Trichlorobenzene	8270	10.0	ND	ND	ND
Benzo(a)anthracene	8270	10.0	ND	ND	ND
Benzo(a)pyrene	8270	10.0	ND	ND	ND
Benzo(b)fluoranthene	8270	10.0	ND	ND	ND
Benzo(g,h,i)perylene	8270	10.0	ND	ND	ND
Benzo(k)fluoranthene	8270	10.0	ND	ND	ND
Benzidine	8270	10.0	ND	ND	ND
1,2-Diphenylhydrazine	8270	20.0	ND	ND	ND
N-Nitrosodimethylamine	8270	20.0	ND	ND	ND
Acenaphthene	8270	10.0	ND	ND	ND
3,4-Benzo-fluoranthene	8270	10.0	ND	ND	ND
4-Chloroaniline	8270	20.0	ND	ND	ND
2-Methylnaphthalene	8270	10.0	ND	ND	ND
2-Nitroaniline	8270	50.0	ND	ND	ND
4-Nitroaniline	8270	20.0	ND	ND	ND
Dibenzofuran	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5C. (CONTINUED) - PRIORITY POLLUTANT ACID EXTRACTABLES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Phenol	8270	10.0	ND	ND	ND
2,4,6-Trichlorophenol	8270	10.0	ND	ND	ND
2-Chlorophenol	8270	10.0	ND	ND	ND
2,4-Dichlorophenol	8270	10.0	ND	ND	ND
2,4-Dimethylphenol	8270	10.0	ND	ND	ND
4,6-Dinitro-o-cresol	8270	50.0	ND	ND	ND
2,4-Dinitrophenol	8270	50.0	ND	ND	ND
2-Nitrophenol	8270	10.0	ND	ND	ND
4-Nitrophenol	8270	50.0	ND	ND	ND
p-Chloro-m-cresol	8270	20.0	ND	ND	ND
Pentachlorophenol	8270	50.0	ND	ND	ND
p-Cresol	8270	10.0	ND	ND	ND
o-Cresol	8270	10.0	ND	ND	ND
2,4,5-Trichlorophenol	8270	10.0	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5C. (CONTINUED) - ORGANOPHOSPHORUS PESTICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Azinphos-methyl	8140	0.20	ND	ND	ND
Bolstar (Sulprofos)	8140	0.14	ND	ND	ND
Coumaphos	8140	0.40	ND	ND	ND
Demeton, -O, -S	8140	0.24	ND	ND	ND
Diazinon	8140	0.40	ND	ND	ND
Dichlorvos	8140	1.60	ND	ND	ND
Dimethoate	8140	0.52	ND	ND	ND
Disulfoton	8140	0.14	ND	ND	ND
EPN	8140	0.08	ND	ND	ND
Ethoprop	8140	0.40	ND	ND	ND
Fensulfothion	8140	0.16	ND	ND	ND
Fenthion	8140	0.16	ND	ND	ND
Malathion	8140	0.22	ND	ND	ND
Merphos	8140	0.40	ND	ND	ND
Mevinphos	8140	1.00	ND	ND	ND
Naled	8140	1.00	ND	ND	ND
Parathion	8140	0.24	ND	ND	ND
Phorate	8140	0.08	ND	ND	ND
Ronnel	8140	0.14	ND	ND	ND
Sulfotep	8140	0.14	ND	ND	ND
TEPP	8140	1.60	ND	ND	ND
Tetrachlorovinphos	8140	1.60	ND	ND	ND
Tokuthion	8140	0.14	ND	ND	ND
Trichloronate	8140	1.60	ND	ND	ND

[a] All results expressed as μg/L.

TABLE A1-5C. (CONTINUED) - CHLORINATED PESTICIDES AND HERBICIDES[a]

Analyte	EPA Method	Detection Limits	25% G.W.	5% G.W.	1% G.W.
Pesticides:					
Aldrin	8080	0.034	ND	ND	ND
Alpha-BHC	8080	0.035	ND	ND	ND
Beta-BHC	8080	0.023	ND	ND	ND
Delta-BHC	8080	0.024	ND	ND	ND
Gamma-BHC (Lindane)	8080	0.025	ND	ND	ND
Chlordane	8080	0.037	ND	ND	ND
4,4'-DDD	8080	0.050	ND	ND	ND
4,4'-DDE	8080	0.058	ND	ND	ND
4,4'-DDT	8080	0.081	ND	ND	ND
Dieldrin	8080	0.044	ND	ND	ND
Alpha-Endosulfan	8080	0.030	ND	ND	ND
Beta-Endosulfan	8080	0.040	ND	ND	ND
Endosulfan sulfate	8080	0.0072	ND	ND	ND
Endrin	8080	0.0072	ND	ND	ND
Endrin Aldehyde	8080	0.0032	ND	ND	ND
Heptachlor	8080	0.0040	ND	ND	ND
Heptachlor Epoxide	8080	0.0042	ND	ND	ND
Methoxychlor	8080	0.0500	ND	ND	ND
Chlorpyrifos	8080	0.0044	ND	ND	ND
Toxaphene	8080	0.0114	ND	ND	ND
Malathion	8080	0.1100	ND	ND	ND
Parathion	8080	0.1200	ND	ND	ND
Dursban	8080	0.0044	ND	ND	ND
Herbicides:					
2,4-D	8150	1.5	ND	ND	ND
2,4,5-TP	8150	0.05	ND	ND	ND

[a] All results expressed as μg/L.